PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

HANSON CREEK DAM
LEWISTOWN, MONTANA
FERGUS COUNTY
MT 01570

prepared for

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

CITY OF LEWISTOWN
(OWNER-OPERATOR)

prepared by

HKM ASSOCIATES
BILLINGS, MONTANA

MARCH 1981

SEATTLE
DISTRICT

UNITED STATES
ARMY CORPS OF ENGINEERS

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EXECUTIVE SUMMARY

Personnel of HKM Associates, under a contract with the Seattle District Corps of Engineers, and with representation from the Soil Conservation Service (SCS), the State of Montana, Department of Natural Resources and Conservation (DNRC), and the City of Lewistown, inspected Hanson Creek Dam on July 24, 1979. The inspection and evaluation was performed under the authority of Public Law 92-367.

Hanson Creek Dam is located on Hanson Creek, approximately 6 miles southeast of Lewistown, Fergus County, Montana. In terms of stream course length, the dam is located about 8½ miles upstream of Lewistown. Dam construction was completed in March 1974.

This report was compiled from information obtained during the on-site inspection, review of construction plans and design files, input from SCS representatives, and an analysis of available hydrologic information. Findings were compared with criteria provided in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

FINDINGS AND EVALUATION

Hanson Creek Reservoir receives runoff from a drainage area of 7.8 square miles. The project is multi-purpose in nature as it provides 125 acre-feet (AF) of sediment storage, 55 AF of recreational water storage, 430 AF of storage in the flood control zone and 250 AF of storage in the flood surcharge zone (Ref. 5). Total storage capacity to the existing first overtopping dam crest elevation is about 860 AF. The dam has a structural height of 72.4 feet and a hydraulic height of 69.2 feet. On the basis of criteria in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. Failure of the dam could endanger many lives and cause extensive property damage. The downstream hazard potential is therefore high (Category 1).

The guidelines recommend that the spillway design flood (SDF) for an intermediate-size, high downstream hazard potential dam must be the Probable Maximum Flood (PMF). The PMF is defined as a flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF resulting from a 72-hour Probable Maximum Precipitation (PMP) has an estimated volume of 6280 AF and a peak flow of 38,100 cubic feet per second (cfs). The emergency and the principal spillway have a combined maximum discharge capability of approximately 14,500 cfs with the reservoir at the first overtopping dam crest elevation (4266.4 feet NGVD). Routing of the estimated PMF was started with the reservoir at the emergency spillway crest, and it was found that the dam

is capable of safely controlling a flood having ordinates approximately equal to 40 percent of the PMF hydrograph ordinates. The embankment materials are classified as being moderately erodible and can be expected to remain stable only for a short period of time under an overtopping condition. A flood event greater than 40 percent of the PMF hydrograph ordinates results in overtopping and failure of the dam. Because the combined arrangement of principal and emergency spillways is incapable of safely handling 1/2 the PMF, the spillway system is seriously inadequate and the dam is considered unsafe (non-emergency) under inspection guidelines.

The embankment structure appears to be in good condition with only minor sloughing of the topsoil at isolated locations on the downstream slope. The seepage control system was satisfactorily accommodating the underseepage at the time of the field investigation. The minimum calculated factor of safety for the steady state condition is below the recommended guidelines. There are no piezometers in the embankment to verify the location of the phreatic surface through the dam. Debris and plant growth was observed on the upstream face.

RECOMMENDATIONS

Immediately develop, implement, and test an emergency downstream warning plan for use in the event of dam distress. Inspect the 24-inch conduit as soon as possible, and repair as required. Provide emergency closure capability of the emergency spillway conduit at the riser. Inspect periodically, and repair areas on the embankment slopes that have experienced topsoil sloughing. Periodically remove large debris from the upstream face and in the immediate vicinity of the principal spillway riser. Repair the concrete deterioration of the outlet structure, and replace the sealant material where the pipe exits into the structure. Periodically inspect the riprap protection blanket on the upstream face for zones of rapid deterioration. On the upstream face, remove plant growth in the riprap section, and add and/or rearrange the rock to cover deficient areas.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate. Install piezometers in the embankment and develop a monitoring program. Reevaluate embankment stability using actual phreatic surface data and conduct periodic inspections of the project at 5-year (maximum) intervals by engineers experienced in dam design and construction. Develop and

implement a periodic maintenance plan for the dam and appurtenant structures. Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC to insure compliance with all pertinent laws and regulations.

Mike Keene

Michael D. Keene
Professional Engineer

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PERTINENT DATA SUMMARY

1. General

Federal ID Number	MT 01570
Owner	City of Lewistown
Operator	City of Lewistown
Purpose	Flood Control, Recreation, Sedimentation
Location	Sections 5 and 8, T14N, R19E, MPM
County, State	Fergus County, Montana
Watershed	Hanson Creek (tributary to Big Spring Creek)
Hazard Potential	Category 1 (High)

2. Reservoir

Surface Area at Emergency Spillway Crest Elevation 4260.0 feet NGVD	32 acres
Storage to Inlet of Low-Level Outlet Elevation 4210.3 feet NGVD	less than 1 acre-foot
100-year Sediment Storage	125 acre-feet
Storage to Principal Spillway Crest Elevation 4241.0 feet NGVD	180 acre-feet
Storage to Emergency Spillway Crest Elevation 4260.0 feet NGVD	610 acre-feet
Storage to Design Dam Crest Control Elevation 4265.5 feet NGVD	820 acre-feet
Storage to First Overtopping Dam Crest Elevation 4266.4 feet NGVD	860 acre-feet
Reservoir Water Surface Elevation on the Day of Inspection (7/24/79)	4241.3 feet NGVD
Drainage Area	7.8 square miles

PERTINENT DATA SUMMARY
(Continued)

3. <u>Principal Spillway</u>

Crest Elevation	4241.0 feet NGVD
Type	Uncontrolled, two-sided inlet, covered riser with 24-inch diameter reinforced concrete steel cylinder pipe 272 feet long.
Dimensions	3 feet by 6 feet
Spillway Capacity (to Design Dam Crest Control Elevation)	102 cubic feet per second
Spillway Capacity (to First Overtopping Dam Crest Elevation)	102 cubic feet per second

4. <u>Emergency Spillway</u>

Crest Elevation	4260.0 feet NGVD
Type	Uncontrolled, channel spillway founded on rock foundation with topsoil
Width	400 feet
Spillway Capacity (to Design Dam Crest Control Elevation)	10,400 cubic feet per second
Spillway Capacity (to First Overtopping Dam Crest Elevation)	14,400 cubic feet per second

5. <u>Outlet Works (Low-Level Outlet)</u>

Gate	24-inch slidegate at inlet
Control	Manual operator
Conduit	
Type	24-inch reinforced concrete steel cylinder pipe
Length	403 feet

6. <u>Dam</u>

Type	Zoned earth fill

PERTINENT DATA SUMMARY
(Continued)

Structural Height	72.4 feet
Hydraulic Height	69.2 feet
Design Crest Control Elevation	4265.5 feet NGVD
First Overtopping Dam Crest Elevation	4266.4 feet NGVD
Crest Length	759 feet
Crest Width	20 feet
Upstream Slope	1V on 4H; 1V on 3H
Downstream Slope	1V on 2.25H; 1V on 2H

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority

This report summarizes the Phase I inspection and evaluation of Hanson Creek Dam, owned by the City of Lewistown, Montana.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam
(2) based upon an evaluation of the available data and a visual inspection
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted
(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed

with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose and Inspection

The findings and recommendations in this report were based on visual inspection of the project, minimal field survey measurements, and a review of available design and operation data. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

The visual inspection of Hanson Creek Dam was made on July 24, 1979. HKM Associates personnel who attended the field inspection and contributed to this report were:

A. T. Kersich, Engineer, Team Leader
Dan Dyer, Geotechnical Engineer
Mike Keene, Hydraulics/Hydrology

Other HKM personnel contributing to the report but not attending the field inspection were:

Dale R. Cunnington, Structural Engineer
Gary Elwell, Hydrology
Dan Nebel, Geology
Kuo-Kung Shih, Hydraulics/Hydrology

Other personnel present during the inspection included:

Loyd Bowen, Superintendent of Operations,
City of Lewistown

Bill Colenso, Soil Conservation Service (SCS), Lewistown office
Glen McDonald, Supervisor, Montana, Department of Natural Resources and Conservation (DNRC), Dam Safety Section
Larry Tegg, Structural Engineer, Montana DNRC, Dam Safety Section

The inspection process allows for report review by: the City of Lewistown; the SCS; and the Montana DNRC. Review comments are considered before final publication of the Phase I Inspection Report. Written responses from the City of Lewistown, SCS, and DNRC are enclosed in Appendix F. The Corps of Engineers' response to the City of Lewistown and SCS comments is also provided in Appendix F.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Hanson Creek Dam is a compacted, zoned earth fill dam located in the SE¼ of Section 5 and the NE¼ of Section 8, T14N, R19E, M.P.M., Fergus County, Montana (Appendix A) (Ref. 2-4). The dam and reservoir form a multi-purpose facility within the Big Spring Creek watershed by containing the flows of Hanson Creek, a tributary of Big Spring Creek (Appendix B). The nearest major community is Lewistown, Montana, which is located approximately 8½ miles downstream of the dam. The Hanson Creek Storage Project is owned, operated, and maintained by the City of Lewistown (Ref. 2, 5).

Hanson Creek Dam has a hydraulic height of 69.2 feet and a maximum storage capacity of 860 acre-feet (AF) to the first overtopping dam crest elevation (4266.4 feet NGVD). Based on a visual reconnaissance and engineering judgment, there is an extensive amount of development and loss of life potential immediately downstream of the structure which could be affected by a sudden breach of the dam. In particular, there are approximately 100 homes and 5 farmsteads located in the flood plain between Hanson Creek Dam and the city limits of Lewistown. Also subject to damage below the dam are: the State Fish Hatchery; the municipal water supply source (springs and collection gallery); farm buildings (non-inhabitable); state, county and private roads and bridges; a section of the Milwaukee Railroad; and miscellaneous utilities. On the basis of this information and in accordance with the recommended guidelines (Ref. 1), the project is classified intermediate in size and the downstream hazard potential is high (Category 1).

The reservoir has capacity for sediment detention, recreational water, and floodwater detention. More specifically, there are 125 AF reserved for 100-years of sediment accumulation, 55 AF for recreational water storage, and 430 AF of

floodwater storage to accommodate the 100-year 10-day flood event. An additional 250 AF are available for flood surcharge storage before overtopping the dam, and can be safely utilized in accommodating more severe flood events (Ref. 2, 5).

Hanson Creek Dam controls runoff from 7.8 square miles of drainage area, or approximately 5.2 percent of the total Big Spring Creek watershed above the community of Lewistown. The contributary watershed is comprised mainly of moderately high mountains and rolling foothills, with elevations ranging from an average of 5100 feet NGVD in the upper reaches to 4241.0 feet NGVD at the reservoir normal water surface level.

1.2.2 Regional Geology

Hanson Creek Dam is located on the north margin of the Big Snowy Mountains in a high, fairly flat table-land that extends to the northeast for 10 or 15 miles. The Big Snowy Mountains consist entirely of sedimentary rocks that have been arched upward in a huge elliptical dome. The mountains form a southeastward trending range about 24 miles long and 6 to 10 miles wide. The Madison Limestone forms the central core of the range. The boundary between mountains and plains is sharp on the south, where the steeply dipping Madison Limestone makes a nearly continuous inclined rocky slope. The north margin of the range is less defined, mainly because these formations dip at a low angle. The prevailing dip on the north side is 8° to 10°. Outside the main mountain slope, which is underlain by Madison Limestone, the limestone beds in the top of the Quadrant formation weather into high bluffs that form the inner fringe of the foothills (Ref. 6).

1.2.3 Seismicity

Hanson Creek Dam is in a relatively quiet seismic zone with the majority of the region's seismic events occurring in the southwestern Montana-Yellowstone Park area. Since 1925, Montana has experienced five shocks that reached intensity VIII or greater (Modified Mercalli Scale). The closest epicenter occurred at Helena, Montana which is approximately 135 miles west of the damsite. No shocks of intensity IV or greater have been reported within a 100-mile radius of the site (as of January 1974). The site is located in zone 2 of the Seismic Zone Map of Contiguous States and may be assumed to present no hazard from an earthquake provided static stability conditions are satisfactory and conventional safety margins exist (Ref. 1, 7).

1.2.4 Site Geology

Hanson Creek was explored by the Soil Conservation Service in 1972. Maps and logs of soil borings are presented on

Sheets 3, 4 and 10 of Exhibit D1, Appendix D. Hanson Creek Dam spans the Hanson Creek Valley for a distance of approximately 760 feet. The valley is formed in gray, drab, brown, and red non-marine shale, mudstone, siltstone, and sandstone of the Morrison formation of late Jurassic age. The left abutment is in a generally shale and mudstone sequence while the right abutment is in a generally more resistant siltstone sequence. The sediments dip moderately to the south-southeast with the beds forming the right abutment projecting beneath the left abutment (Ref. 5, 8).

Hanson Creek is located near mid-valley, and based on SCS boring logs, is underlain by a maximum of 20 feet of an alluvial clay and gravel sequence. The right valley floor is a terrace consisting of up to 25 feet of alluvial clay and gravel. The left valley floor is a bedrock knob overlain by deep colluvial soils and weathered bedrock (Ref. 5, 8).

1.2.5 Design and Construction History

Hanson Creek Dam was designed and constructed under authority of Public Law 566, 83d Congress. Design and construction inspection was provided by the Soil Conservation Service. Wickens Brothers of Lewistown, MT was the construction contractor. Construction began essentially in January 1973 and was completed in March 1974. Some of the revegetation work extended into May 1974.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway system for Hanson Creek Dam consists of a principal and emergency spillway. The principal spillway is located approximately 250 feet from the right abutment contact, is aligned perpendicular to the centerline of the dam, and lies approximately in the valley bottom. It consists of a reinforced concrete riser, approximately 272 lineal feet of 24-inch diameter reinforced concrete steel cylinder conduit, and a reinforced concrete energy dissipator (impact basin). The riser is uncontrolled and designed according to SCS standards for covered, two-sided, pipe inlet spillways (Ref. 10). Riser dimensions are 3 feet by 6 feet, and stands approximately 40 feet above the 24-inch diameter conduit (Photo 4 of Appendix C and Sheets 11, 15 and 16 of Exhibit D1, Appendix D). The principal spillway conduit is an extension of the low-level outlet system. It is supported by a reinforced concrete cradle and either a natural shallow layer of sands and gravels, or a small amount of backfill. The bedding lies immediately above a hard shale bedrock (Sheets 11, 12 and 18 of Exhibit D1, and Ref. 23). The exception to this bedding situation is where the conduit crosses the cutoff trench at which point it rests on about 2½ feet of compressible material. Antiseep collars are located throughout the impervious zone material. According to the SCS field inspection reports (Ref. 23) and the "as-built" drawings, the conduit and cradle were placed on a uniform grade of 0.1 percent to construction station 9+93. An increase in slope occurs in the next four pipe joints to station 9+45. From this point to the riser, the conduit was placed on a uniform grade of 3.49 percent (Sheets 11 and 12 of Exhibit D1). A detailed discussion of the conduit specification is presented in Section 2.1.2.

High velocity flows and excess energy are dissipated in a baffled impact basin outlet structure before the discharge empties into a return channel (Photo 6 of Appendix C and Sheets 12, 19 and 20 of Exhibit D1). The impact basin was lowered 1.4 feet below the design elevation to be properly embedded in hard shale (Sheet 12 and Ref. 23). Flow is returned to the natural channel of Hanson Creek by way of a 290-foot man-made section (Photos 6 and 7 of Appendix C). The man-made section is trapezoidal in shape with a 10-foot base width, 1 vertical (V) on 2 horizontal (H) side slopes, and constructed on almost a horizontal gradient (Sheet 12 of Exhibit D1).

The principal spillway riser and the 24-inch diameter conduit were not inspected during the Phase 1 investigation because the reservoir pool was at too high a level. A surficial examination was made of the riser hood and the outlet structure, and a detailed inspection of the return channel was performed.

There was a small amount of water entering the spillway riser and passing through the conduit at the time of the inspection. No major structural or operating problems were evident at this reservoir level. Minor concrete deterioration was noted on the impact basin (outlet structure). Some debris is collecting at the riser (Photo 4 of Appendix C). The return channel appeared to be stable and in good operating condition (Photo 7 of Appendix C). The return channel is constructed on a very flat gradient, but does not appear to be adversely impacting the hydraulics of the system.

The principal spillway crest is positioned at the normal pool elevation (4241.0 feet NGVD). The top elevation of the outlet structure sill coincides with the beginning invert elevation of the return channel, which is at elevation 4197.2 feet NGVD. Maximum capacity of the principal spillway at the first overtopping dam elevation is 102 cubic feet per second (cfs). It appears that the conduit will begin flowing full for most of its length at a flow of approximately 80 cfs, which has an associated reservoir pool elevation of 4243.0 feet NGVD. Hence, pressure flow is expected to be in evidence for reservoir pool levels between elevation 4243.0 feet NGVD and first overtopping the dam. Rating information was obtained from the SCS design files and approximately verified using SCS technical release information (Ref. 10). It appears the SCS used a Manning's "n" value of 0.011, and made allowance for trash rack, entrance and exit losses. Stage-discharge information is provided in Exhibits E3 and E4 of Appendix E.

The emergency spillway is located in sandstone on the left abutment. The spillway section is trapezoidal in shape with a base width of 400 feet, and cut slopes of 1V on 2H and 1V on 3H on the left and right side, respectively. There is a 300-foot control section located approximately along the dam centerline axis, but slightly skewed relative to the dam axis. The control section is leveled to elevation 4260.0 feet NGVD and covered with a thin layer of topsoil (Sheet 8 and 9 of Exhibit D1). Design notes indicate that the sandstone materials are relatively soft and moderately erodible, but were considered adequate for the infrequent low duration flows. It is expected that the topsoil will be plucked along the excavated section and rather severe erosion can be expected to occur in the outlet channel as it approaches the valley. The spillway outlets in a draw at least 600 feet downstream from the toe of the dam. It is not anticipated that the plucking and erosion will affect the structural

integrity and safety of the embankment structure as the areas of anticipated high scour activity are comfortably removed from the embankment site. Photo 4 of Appendix C shows the inlet into the emergency spillway, and Sheets 2, 8 and 9 of Exhibit D1 contain structural details.

The emergency spillway has never operated since project construction. A visual examination of the spillway facility revealed a good stand of vegetative cover in the channel section. Basically, the emergency spillway is in excellent condition.

The emergency spillway width and dam crest height were originally designed according to SCS standards and guidelines which were applicable at the time of design (Ref. 9). Under maximum surcharging conditions to the dam overtopping elevation (4266.4 feet NGVD), the emergency spillway capacity is estimated to be 14,400 cfs. Discharge rating information was obtained from the SCS design files and approximately verified using SCS technical release publications (Ref. 11, 12). The verification of the SCS rating data involved taking the given reservoir stage-spillway discharge information and incorporating it into a specific energy/energy loss relationship (Ref. 11). The only unknown in the relationship was Manning's "n" value, which is contained in the friction loss term. In solving the relationship for "n", it was found that the SCS used a "n" value in the range of 0.032 to 0.035. This range is considered reasonable for the channel involved, hence, the SCS information was used for the Phase 1 inspection without modification. The discharge rating information is provided in Exhibits E3 and E4.

2.1.2 Low-Level Outlet

A low-level outlet gate and horizontal conduit are provided to permit outflow during construction and to allow complete drawdown of the normal pool. The drawdown conduit is incorporated with the principal spillway conduit. The inlet consists of a trash rack, a 24-inch slide gate, and a reinforced concrete structure having an inlet elevation of 4210.3 feet NGVD (Sheet 13 of Exhibit D1). The manual controls for the slide gate were designed following the criteria outlined in Reference 13. The controls are located on a local berm at elevation 4245.0 NGVD and are shown in Photo 5 of Appendix C. The berm and controls are situated such that they do not interfere with the hydraulics of the principal spillway riser (Sheet 11 of Exhibit D1). The inlet structure is connected to the spillway riser by approximately 131 lineal feet of 24-inch diameter reinforced concrete steel cylinder pipe. Pipe slope from the inlet structure to the riser is 6.26 percent. The low-level outlet system and principal spillway utilize a common 24-inch conduit for the remaining distance under the embankment, and a common outlet structure (Sheets 11 and 12 of Exhibit D1). The conduit is supported

throughout its total length by a reinforced concrete cradle. The conduit and cradle upstream of the riser are founded on the sands and gravel materials above the hard shale bedrock. In the few locations where sands and gravels were not encountered at planned grade, the softer in situ materials were removed and the overexcavations backfilled with compacted sands and gravels.

The SCS design files and report indicate that the conduit was designed as a positive projecting rigid conduit. The foundation was assumed to be non-yielding (Ref. 5). The joint extensibility for a 16-foot length of pipe was specified to be 1.0 inch, and the minimum joint limiting angle was specified to be 1°00'. Minimum hydrostatic pressure strength was set at 45 feet of water (Sheet 18 of Exhibit D1 and Ref. 5). Information relative to what was actually furnished and installed was not available for this report, but evidently is available in the Bozeman office of the SCS. No field pressure testing was required for this conduit.

All elements specific to the outlet works which were inspected appear to be in satisfactory operating condition. The gate was partially opened during the inspection, and the low-level outlet system was operated for a short period of time. Inspection of the conduit and gate was not possible due to the height of the reservoir pool at the time of the field inspection. Refer to Section 2.1.1 for the assessment of physical conditions relative to the impact basin and return channel.

Outlet works hydraulic rating information was not available from the SCS and not independently developed for this study. The low-level outlet does not play a role in establishing the hydraulic adequacy of the project. More specifically, it is considered unlikely that the low-level outlet would be utilized during a major flood event because it is normally in the closed position, the manual operator may be inaccessible during high runoff periods, and its contribution to outflow is small compared to other outflow systems. Outlet works rating information is important, however, when considering the drawdown capability in the event of an emergency. This information can be obtained from the SCS or independently developed in subsequent studies if required.

2.1.3 Freeboard

The dam overtops during the guidelines' (Ref. 1) recommended spillway design flood (PMF), therefore no freeboard exists for such conditions. The normal freeboard for Hanson Creek Dam is about 25.4 feet with respect to the existing dam crest overtopping elevation of 4266.4 feet NGVD. Freeboard during the 100-year 10-day event is 6.4 feet. At the time

of the field inspection, the reservoir water surface elevation was approximately 0.3-foot above the normal water surface elevation, or a freeboard of 25.1 feet.

The historical highwater level was experienced during the spring runoff of 1975 when the reservoir pool raised to an approximate elevation of 4246.0 feet NGVD, which leaves 20.4 feet of freeboard. This same highwater level is 3 feet below the rock riprap protection and 14 feet below the emergency spillway crest (vertical distances). The effective fetch length for Hanson Creek Dam at the crest elevation is slightly less than ½ mile, hence wave heights should not be expected to exceed about 2 feet and maximum wave runup should be about 3 feet for the rock riprap and 3.5 to 4 feet for the sod (Ref. 14).

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

Hanson Creek originates in the lower foothills of the Snowy Mountains, and basically drains rangeland and cropland with some timbered areas. The creek meanders through a relatively narrow valley before entering Hanson Creek Reservoir about one-half mile south of the State Fish Hatchery. The drainage basin upstream of Hanson Creek Dam comprises 7.8 square miles and is basically teardrop-shape with the largest portion of the tear at the downstream end of the watershed (Appendix B). The surface area of the reservoir at the normal pool level is about 14 acres.

Soils in the Hanson Creek watershed fall primarily into three physiographic land forms: the foothill soils, benchland soils, and alluvial soils along the stream valleys. Soils along the foothills consist of moderately deep loams and stony loams developed largely from sandstones and shales. The major portion of the foothill area is native range, and only about 10 percent of the small foothill areas consist of steep rock ridges which are partially timbered. Soils on the benchland are characterized by a silt loam surface soil of relatively shallow depth underlain by heavy clay loam. Bedrock consists of fractured sandstones, shales, and limestones. Drainage of the surface soil is moderate but noticeably restricted in the lower horizon. Alluvial soils occupy flood plains and terrace benches along stream valleys, and generally vary a considerable amount in texture and depth. Alluvial soils through the foothills are largely stony riverwash developed on relatively narrow flood plains (Ref. 2).

The climate of the area around Hanson Creek Dam has many features associated with the "continental" type, but occasionally is influenced by Pacific and Gulf weather patterns.

While cold arctic air masses usually invade the area from a few to several times each winter, they seldom cover the area for more than a few days at a time. These cold air masses are usually succeeded by warm, dry winds which can blow for a week or more several times each season. Besides the warm winds, the occasional heavy winter snowfall in the local mountain ranges also deviates from the true continental climate. The average annual precipitation for Lewistown, which is located approximately 6 miles northwest of Hanson Creek Dam, is 17.47 inches. Of this amount, about 45 percent of it falls during the average 107-day frost-free period of June 2 to September 17. Killing frosts have been recorded as late as June 25 in the summer and as early as July 30 (Ref. 15, 16). The annual precipitation increases rapidly as elevation increases in the watershed. A climatological station (Lewistown 10S) located ten miles south of Lewistown and 805 feet higher than the station at the Lewistown airport, has an average annual precipitation of 23.5 inches. The two largest annual values for the period of record starting in June 1949 occurred in the years 1964 and 1978. For comparison purposes, the Lewistown 10S station recorded 31.51 inches in 1964 compared to 22.64 inches at the airport. And for 1978, Lewistown 10S recorded 34.32 inches compared to 28.11 inches at the airport (Ref. 16).

Snowpack and water content has been monitored for several years at the Crystal Lake Snow Course. This particular station is located in the Big Snowy Mountains and has an elevation of 6100 feet NGVD. Water content on April 1 averages in excess of 12 inches (Ref. 2, 17, 18).

The average temperature at the Lewistown airport, according to records up through 1978, is 41.9 degrees Fahrenheit. Monthly average temperature for January is 19.1 degrees Fahrenheit, for April is 40.1 degrees Fahrenheit, for May is 49.6 degrees Fahrenheit, and for July is 65.5 degrees Fahrenheit (Ref. 16).

Major floods have historically occurred when high intensity precipitation falls on above normal, ripe snow packs or on frozen soil conditions. Flooding has also occurred due to rapid melting of the snow pack with little or no added precipitation.

2.2.2 Estimated Probable Maximum Flood (PMF)

The inspection guidelines recommend that the spillway design flood (SDF) for a project of this type be the probable maximum flood (PMF). The PMF is defined as a flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the study region. The PMF is derived from the probable maximum precipitation (PMP) with appropriate consideration

of snowmelt contributions. The procedures contained in the National Weather Service Technical Paper 38 (Ref. 19) were used to compute the 1 to 24-hour PMP values. As per direction by the Seattle District, U.S. Army Corps of Engineers, the 24-hour PMP was extended to 48-hour and 72-hour durations by applying a factor of 110 percent and 115 percent, respectively. The PMP 1-hour, 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour precipitation values are 9.0 inches, 14.6 inches, 16.7 inches, 18.7 inches, 20.6 inches, and 21.5 inches, respectively. The 6-hour increments for the total 72-hour storm were arranged in a critical distribution using criteria presented in the National Weather Service Hydrometeorological Report No. 43 (Ref. 20). In particular, the 6-hour rainfall increments were arranged according to pattern "e". Further subdivision of rainfall increments was required to be compatible with the selected duration of the unit hydrograph. In the case of Hanson Creek Dam, a 15-minute unit hydrograph was selected using criteria presented in the SCS Hydrology Handbook (Ref. 9). The PMP storm was plotted in the form a depth-duration curve for convenience in selecting incremental rainfall values. The 15-minute PMP values within the time base of the unit hydrograph were ordered according to the reverse pattern of the unit hydrograph ordinates.

Constant rainfall losses were assumed equal to 0.15 inches/hour. This assumption is based on available soil type, land use information and the possibility of antecedent storms saturating the soil prior to the PMF.

The runoff condition, or PMF, resulting from a PMP storm was estimated using the PMP values and the unit hydrograph approach. A 15-minute unit hydrograph was developed for the Hanson Creek Basin using the U.S. Army Corps of Engineers computer program HEC-1 and the SCS method (Ref. 22, 9).

The resultant PMF has a peak flow of 38,100 cfs and a total volume of 6280 AF.

2.2.3 Flood Routing

The PMF resulting from the PMP rainfall/runoff event was routed through Hanson Creek Reservoir using the computer program HEC-1 (Ref. 22). The SCS 100-year 10-day storm was assumed to occur prior to the PMF and the initial reservoir level was assumed to be at the emergency spillway crest. Because only a few elevation-capacity data points were available from the SCS (Exhibit E1.1), it was necessary for routing purposes to perform a supplemental analysis to obtain a more complete tabulation and curve. The results of this analysis are considered to be reasonably representative of the SCS data, and hence, were used in the routing exercise. The estimated area-capacity-elevation results are tabulated and plotted in Exhibits E1.2 and E2.

For the purpose of flood routing and according to Seattle District, Corps of Engineers, Phase I criteria, the dam crest elevation is the lowest elevation of any point on the dam crest. This criteria assumes overtopping and failure of embankment-type dams to be coincidental. Based on the embankment profile survey dated August 2, 1979 (Exhibit D2), the existing first overtopping dam crest elevation is 4266.4 feet NGVD.

Flood routing studies indicate that during the full PMF, Hanson Creek Dam would be overtopped when 35 percent of the flood volume had entered the reservoir. Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can safely contain. The hypothetical hydrographs are obtained by applying the same percentages to all PMF hydrograph ordinates. A flood having hydrograph ordinates corresponding to 40 percent of the PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

The geotechnical evaluation of Hanson Creek Dam included a field investigation, and a search and review of project design data. The field inspection consisted of a visual inspection, photo documentation, a dam crest profile survey, estimates of seepage flows through the abutment and embankment drains, slope stability observations of the embankment, and measurements of the slope angles. Inspection photos are included in Appendix C, and the crest profile survey is shown in Exhibit D2 of Appendix D. Results of the seepage estimates and the slope angle measurements are provided in Exhibit D3.

2.3.1 Dam Embankment

Hanson Creek Dam is a compacted, zoned, earth fill structure (Ref. 5) which was completed in 1974. The dam has a structural design height of 72.4 feet and a crest length and width of 759 feet and 20 feet respectively. The "as-built" plans indicate the contractor optioned to overbuild the dam crest with topsoil. The crest currently has a mean elevation of about 4268.15 feet NGVD (Exhibit D2), compared to the SCS estimate for the final settled dam of 4265.5 feet NGVD. Construction plans indicate the upstream face has a slope of 1V on 3H down to the normal pool elevation (4241.0 feet NGVD). A field measurement of this portion of the slope indicates the existing face is about 1V on 2.4H which is steeper than the slope on the construction plans. There is a 25-foot wide berm located on the upstream slope at the

normal pool elevation. Below this berm the upstream face flattens to a slope of 1V on 4H. This portion of the slope was inundated at the time of the investigation. Riprap, having a maximum nominal size of 18-inches, extends upslope to elevation 4249.0 feet NGVD. The downstream slope is 1V on 2H from the dam crest to elevation 4241.0 feet NGVD, then flattens to 1V on 2.25H to the downstream toe. Field measurements approximately verify these slopes.

Slope angles were measured during the field investigation and the results are shown in Exhibit D3 of Appendix D. The slope angles were measured with an Abney level and should be considered approximate. It should be noted from the exhibit that the upstream slopes appear slightly steeper than designed. This is probably due to spillover of topsoil which was being placed to obtain desired overbuild.

There is a 10-foot wide berm located on the downstream face at elevation 4241.0 feet NGVD which has a slight back slope for runoff control. Both the upstream slope above the riprap and the downstream slopes have been covered with topsoil and vegetated. There is a dense cover of natural grasses and weeds on both slopes (Photo 2 of Appendix C).

Sheets 5 and 6 of Exhibit D1 show the cross section of the dam to consist of four (4) distinct zones and identified as Zones I, II, III, and IV. Zone I material comprises the large upstream section and consists of silty sandy clays and clayey sands. The specifications call for that portion of Zone I material passing the three (3) inch opening to contain not less than thirty-five (35) percent fines (200 screen). This specification indicates that the Zone I material should be relatively impervious.

Zone II is a pervious gravel drain fill material. This zone was included to control the anticipated seepage through the Zone I embankment section.

Zone III material consists of sandy silty gravels, gravelly sands, shales, sandstone, and limestone rock from excavation of the emergency spillway. This zone forms the downstream section of the embankment.

Zone IV material also consists of sandy silty gravels, gravelly sands, and sandstone and limestone rock fragments which are primarily bedding material for riprap.

Extensive inspection was performed by the SCS during the construction of the dam. Quality control tests were also performed to verify compaction densities and material types.

2.3.2 Foundation Conditions, Seepage, and Drainage

Based on field observations, available drill logs, and the dam profile in the construction plans, the majority of the embankment is founded on weathered bedrock. A short section of the embankment between station 13+00 and station 15+00 (SCS survey) is underlain by natural alluvial deposits of clay and gravel. A cutoff trench was constructed along the entire length of the embankment and extends to relatively hard bedrock (see Sheet 4 of Exhibit D1). This trench is 20 feet wide at the base and backfilled with Zone I material.

Settlement

Foundation and embankment settlement were evaluated utilizing the field observations, the profile survey, and the elevations on the construction plans. The construction plans indicate the dam crest was to be cambered, with the amount of camber over a specified minimum being optional to the contractor. Camber specifications stated a minimum crest elevation of 4266.9 feet NGVD throughout the central portion of the embankment, which is equivalent to a 1.4-foot overbuild. The overbuild amount was designed to transition to the final crest control elevation of 4265.5 feet NGVD at both abutments. The crest profile survey of August 1979 shows a minimum crest elevation of 4266.36 feet NGVD on the right side, and a mean maximum elevation throughout the central portion of the embankment of 4268.15 feet NGVD. Because final construction elevations are not provided on the "as-built" drawings, the amount of constructed overbuild and post-construction settlement are indeterminate. However, the crest appears relatively uniform which suggests a minimum amount of differential settlement. Because the embankment is constructed primarily on bedrock, it can reasonably be assumed that most settlement will be a result of consolidation of the embankment material. Future settlement in any portion of the embankment is expected to be minimal.

Seepage Control

An estimation of the observed seepage being collected in the drain system from the abutments and through the embankment was made during the field investigation. The total observed seepage from the three drain exits were estimated to be 7 gallons per minute. The design estimate was 10.7 gallons per minute. Because the drain pipes are encased in gravel drain fill material, the observed seepage may represent only a portion of the total. As the embankment drain pipes extend into both abutments, embankment seepage cannot be differentiated from abutment seepage.

All the seepage water was clear. The pool elevation at the time of the investigation was 4241.3 feet NGVD which is 0.3 foot above normal pool. In addition, the design estimate represents the total seepage whereas the field observation of the outlets probably only represents a portion of the total seepage.

The seepage through the embankment is being intercepted by the 5-foot wide chimney drain and carried through a 6-inch perforated collector pipe to the principal spillway headwall. There are no piezometers located in the embankment to verify the location of the phreatic surface through the dam. However, the system appears capable of satisfactorily handling this volume. Discharge from the left abutment is much less than anticipated. In general, the entire seepage control system appears to be operating satisfactorily and has reserve capacity to handle additional seepage if necessary.

2.3.3 Stability

Visual inspection of the embankment slopes indicate that minor sloughing is occurring at various isolated locations on the downstream slope. This sloughing appears to be shallow and to include only the topsoil.

A slope stability analysis was performed by the SCS using a modified version of the computerized New York State Method of Slices. Soil parameters used in the SCS analysis were determined by extensive field and laboratory testing. About 30 drill holes and 46 test pits were considered in the design program. Lab testing included unconfined compression, consolidated-undrained triaxial, and direct shear strength tests. Design studies included a seepage analysis with numerous field permeability tests and flow net calculations.

The computerized slope stability analysis performed by the SCS included seismic loading. Seismic forces were evaluated using a static coefficient of horizontal acceleration equal to 0.1g. The following minimum factors of safety (FS) were calculated:

> Upstream Face Sudden Drawdown Condition
> FS = 1.069 (drawdown & seismic loading)
> FS = 1.266 (drawdown)
>
> Downstream Face Steady State Seepage Condition
> FS = 1.131 (seismic loading)
> FS = 1.358 (without seismic loading)

A summary of the soils properties used in the original design are presented in Exhibit D4.

In summary, no outward distress or stability problems are evident. The calculated factors of safety for Hanson Creek Dam meet the Recommended Guidelines for Safety Inspection of Dams (Ref. 1) except for the steady state seepage condition where FS = 1.358 which is less than the recommended FS = 1.50.

Riprap

The riprap material on the upstream face of the dam and on the banks of the downstream channel below the impact basin (outlet structure) consists of calcarious sandstone and limestone. This material is erosion resistant and appears to be performing adequately. Some debris accumulation was observed on the riprap face particularly near the principal spillway inlet. Cattails and other plants are growing in the riprap on the upstream slope. Additional rock riprap material, placed in deficient areas, would enhance the protection and discourage plant growth. Photos 2 and 3 of Appendix C provide a photo-view of riprap conditions on the upstream face.

2.4 PROJECT OPERATIONS AND MAINTENANCE

The Hanson Creek Storage Project is owned, operated, and maintained by the City of Lewistown. The multi-purpose reservoir is intended to provide floodwater detention, sediment storage, and recreation water storage. Stored waters are not to be withdrawn below the elevation of the normal (permanent recreational) pool except as deemed desirable for necessary repairs and maintenance, or operation for recreation, fishery or wildlife management. Floodwater is to be stored and then automatically and slowly released. The SCS maintenance plans for this project includes, but is not limited to: keeping all structures in serviceable condition by replacement and repair of structures and outlets as needed during the life of the project; cleaning of the principal spillway inlet and outlet structure and removal of large floating debris; maintaining protective vegetative covering and riprap where needed; periodic or annual restocking of trout; and periodic replacement and repair of the recreational facilities. Occasional maintenance and repair will be required of the private road along the emergency spillway sideslope as a result of severe damage which is anticipated when the spillway flows near capacity. It was suggested by the SCS that the drawdown gate be opened at least once a year to keep sediment from piling up on the gate (Ref. 2 and 5). No operations manual for the project has been prepared, and no operations records are kept.

2.4.1 Dam

The SCS has provided technical assistance and has made modifications where required to meet performance standards.

Basically the dam has not required a considerable amount of maintenance since its original construction in 1974.

2.4.2 Reservoir

The reservoir level is measured once each month at the staff gage on the principal spillway riser. Monitoring is performed by the SCS. No other records or measurements have been kept relative to reservoir inflow and outflow. The low-level outlet normally remains in the fully closed position. Keys for padlock and chain on the operator crank are kept in the office of the Superintendent of Operations, City of Lewistown.

2.4.3 Warning System

There is no formal warning system or plan of action in the event of dam distress.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in accordance with the guidelines (Ref. 1) and the contract performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with inspection guidelines (Ref. 1), Hanson Creek Dam is intermediate in size and, based on our visual inspection and engineering judgment, it has a high downstream hazard potential. Therefore, the guideline's recommended spillway design flood (SDF) for this project is 100 percent of the PMF. Based on reconnaissance level investigations, the project is incapable of handling a flood having one-half the PMF hydrograph ordinates without overtopping and causing the dam to fail which, in our judgment, would seriously jeopardize life and property downstream. Under the inspection criteria, Hanson Creek Dam is considered unsafe, non-emergency until the recommended actions are complete.

3.1.2 Spillway

The principal spillway and the crest of the emergency spillway were designed to accommodate the 100-year 10-day flood event as determined by the SCS. The emergency spillway size and dam crest were also established according to the SCS criteria (Ref. 2, 5, 9). According to the guidelines (Ref. 1), however, the spillway system is considered seriously inadequate. The spillway facilities appeared to be in good physical condition.

It appears that the conduit will operate as a pressure conduit when the reservoir is approximately at or above elevation 4243.0 feet NGVD. Consequently, it is possible that the conduit would be pressurized for several days while a flood event is being accommodated.

The PMF for the 7.8 square-mile drainage area is estimated to have a peak runoff value of 38,100 cfs and a total runoff volume for the 72-hour PMP storm of 6280 AF. The maximum discharge capacity for combined spillway operation, assuming the reservoir pool is at the first overtopping dam crest elevation, is approximately 14,500 cfs. Floodwater storage capability consists of 430 AF between the crests of the principal and emergency spillways, and 250 AF between the crest of the emergency spillway and the first overtopping dam crest elevation. Total floodwater detention storage amounts to 680 AF. The combination of reservoir discharge

and storage capabilities is inadequate to prevent overtopping of the dam during the PMF. In fact, Hanson Creek Dam is overtopped after only receiving about 35 percent of the total PMF volume. National Dam Safety Inspection Program criteria (Ref. 1) recommends the Hanson Creek project be capable of safely handling the full PMF.

3.1.3 Low-Level Outlet

The outlet works inlet structure, including the slide gate, and the 24-inch conduit were not inspected due to the reservoir pool level and operation of the principal spillway. Components of the low-level outlet facility which were examined appeared to be in good operating condition. Minor concrete deterioration was observed in the impact basin. Also, the sealant is deteriorating where the 24-inch pipe exits into the impact basin. The controls are located within the flood control pool on the upstream face of the embankment and, hence, would occasionally be inaccessible. The inaccessible period would last several days during the 100-year 10-day flood event, and longer if an obstruction occurs in the principal spillway or if it is a more severe flood event.

3.1.4 Dam Embankment

Hanson Creek Dam appeared to be stable and in good condition. However, the minimum calculated stability factor of safety for the steady state condition is below the recommended guidelines. There are no piezometers in the embankment to verify the location of the phreatic surface through the dam.

Topsoil sloughing on the downstream embankment slope was evident. Debris and plant growth was observed on the upstream slope. Recommendations have been prepared accordingly.

3.1.5 Geology

The valley floor in the vicinity of Hanson Creek Dam consists of alluvial deposits overlying shale, mudstone, siltstone, and sandstone. The left abutment is in a generally shale and mudstone sequence while the right abutment is in a generally more resistant siltstone sequence. A portion of the embankment is founded on alluvial deposits of clay and gravel. No major bank or shoreline instability was evident.

Hanson Creek Dam is located in a relatively quiet seismic area.

3.1.6 Operation and Maintenance

The dam is visited at least once monthly to monitor the reservoir level, generally by SCS personnel. Also, City of Lewistown personnel frequently visit the site to maintain the recreational area. The reservoir is self-regulating due to the uncontrolled principal spillway. There is no downstream warning system.

3.2 RECOMMENDATIONS

(1) Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam distress.

(2) Inspect the 24-inch conduit, both upstream and downstream from the principal spillway riser, and repair as required. Provide emergency closure capability of the principal spillway conduit at the riser.

(3) Periodically inspect embankment slopes for sloughing. Repair areas on embankment slopes that experienced soil sloughing.

(4) Periodically remove large debris from the upstream face and in the immediate vicinity of the principal spillway riser.

(5) Repair the concrete deterioration of the outlet structure, and replace the sealant material where the 24-inch pipe exits into the structure.

(6) Inspect the riprap protection blanket at least annually for zones of rapid deterioration. Remove plant growth in the riprap section, and add and/or rearrange rock to cover deficient areas.

The above recommendations will not make the project safe but will reduce involved risks while the following recommendations with subsequent actions are being accomplished.

(7) Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate.

(8) Install piezometers in the embankment to monitor the phreatic surface through the structure. Re-evaluate the stability of the embankment using the actual maximum phreatic surface in relation to that assumed in the original stability analyses. Piezometer installation and monitoring, and stability evaluation must be conducted under the direction of a qualified geotechnical engineer. Modify the

embankment if studies indicate to bring the dam into conformance with the inspection guideline's stability criteria. Develop a follow-up monitoring program.

(9) Conduct periodic inspection by qualified engineers at least once every five years to determine whether there are any deficiencies in the condition of the project, adequacy and quality of maintenance, and methods of operation. Include the inspection of the 24-inch diameter outlet works and principal spillway conduit as part of this program.

(10) Develop and implement a periodic maintenance plan for the dam and appurtenant structures.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC to insure compliance with all pertinent laws and regulations.

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21. U.S. Geological Survey, Water Resources Data for Montana, - 1977.

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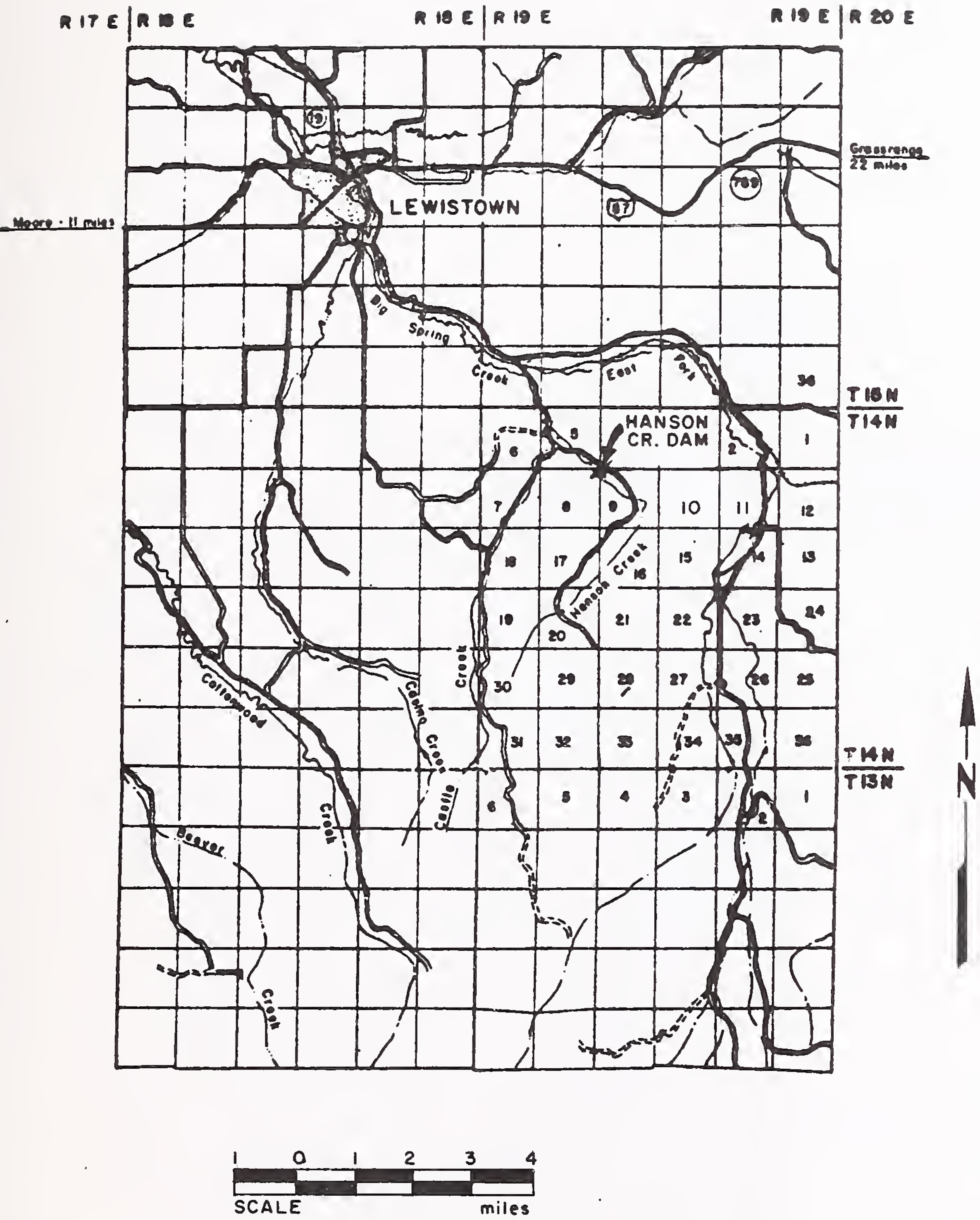
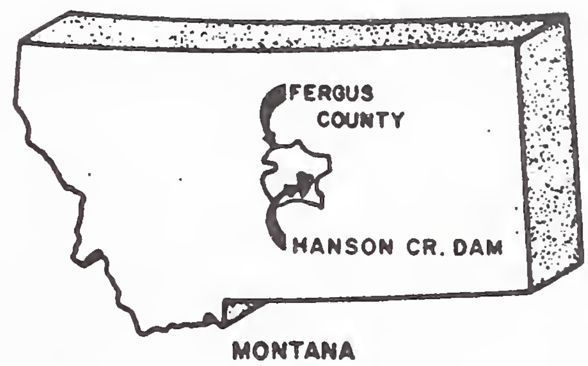
APPENDIX A

HANSON CREEK DAM - VICINITY MAP



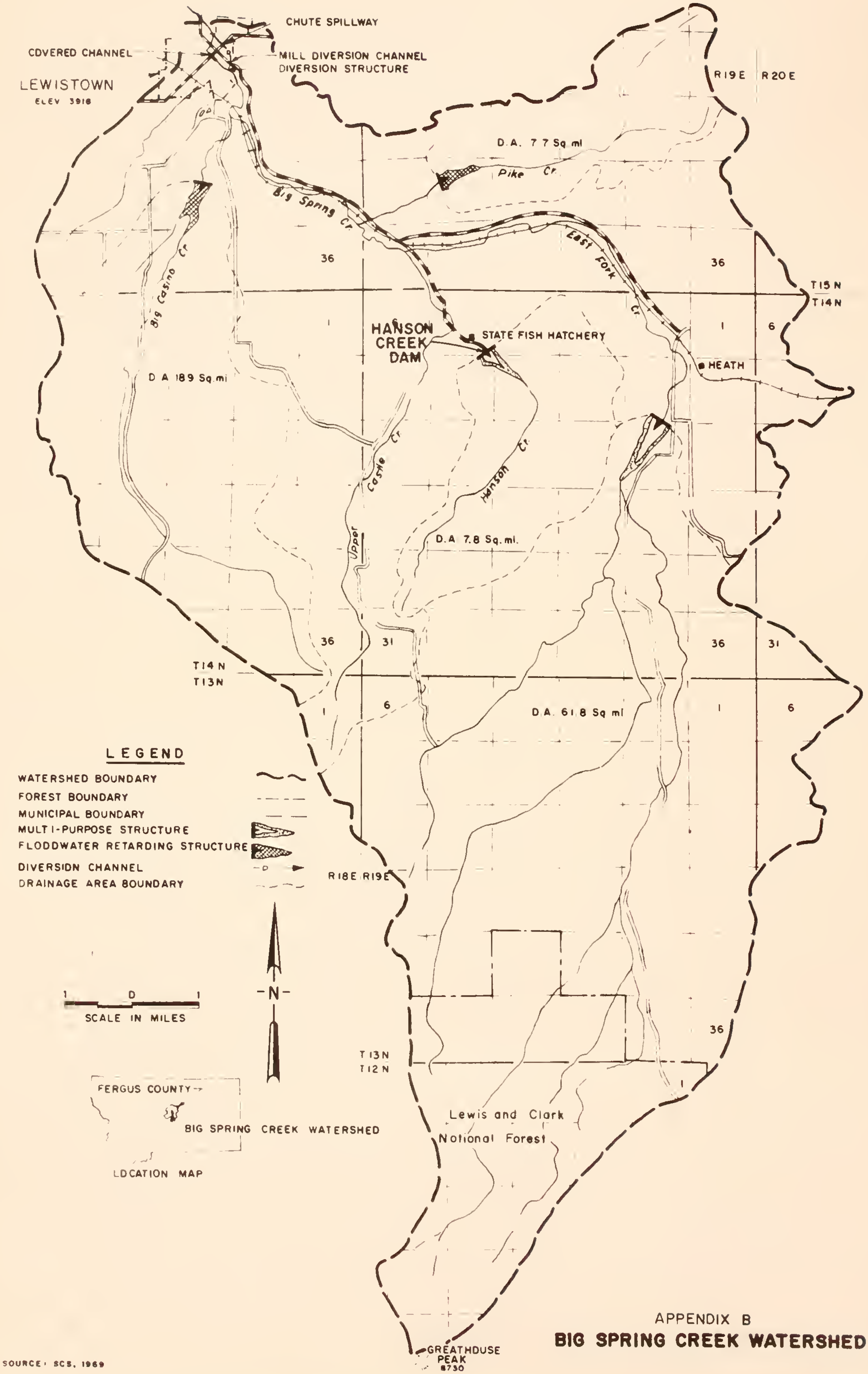


APPENDIX A

VICINITY MAP
HANSON CREEK DAM

APPENDIX B

HANSON CREEK DAM - WATERSHED MAP



APPENDIX B
BIG SPRING CREEK WATERSHED

SOURCE: SCS, 1969

APPENDIX C

HANSON CREEK DAM
INSPECTION PHOTOS

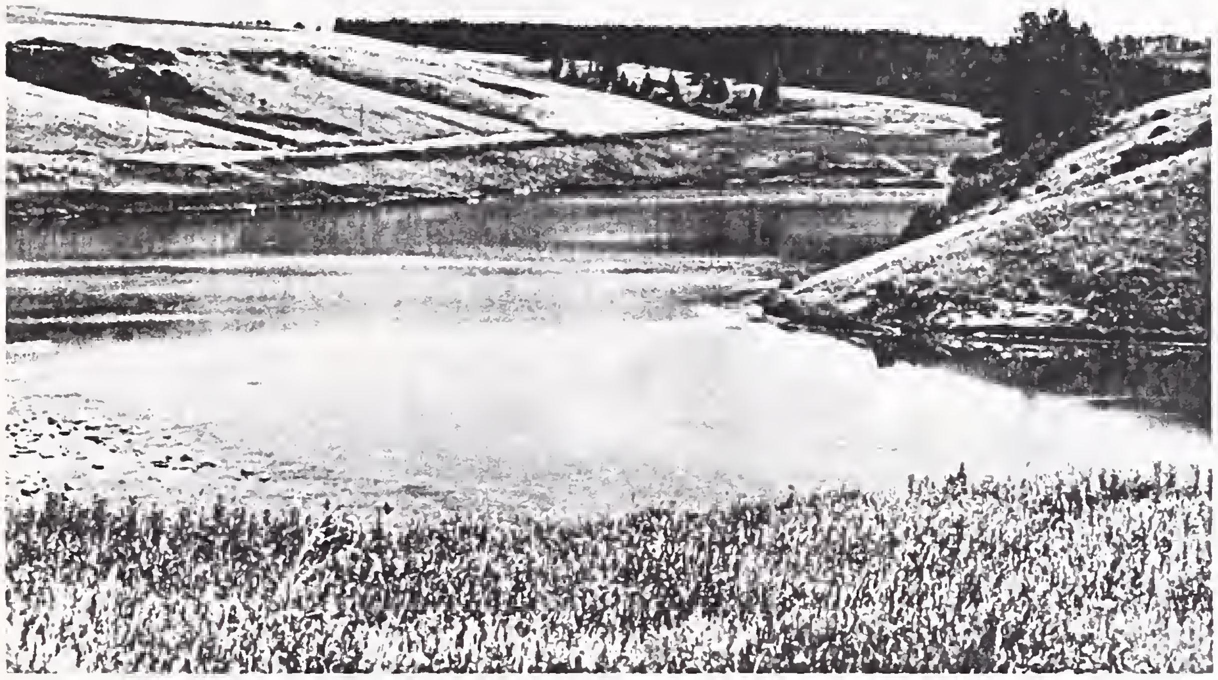


PHOTO NO. 1 - Hanson Creek Reservoir. Standing on embankment near emergency spillway entrance, looking upstream into the basin.

PHOTO NO. 2 - Upstream embankment face. Notice vegetation above rock riprap. Also note vegetation in rock area.

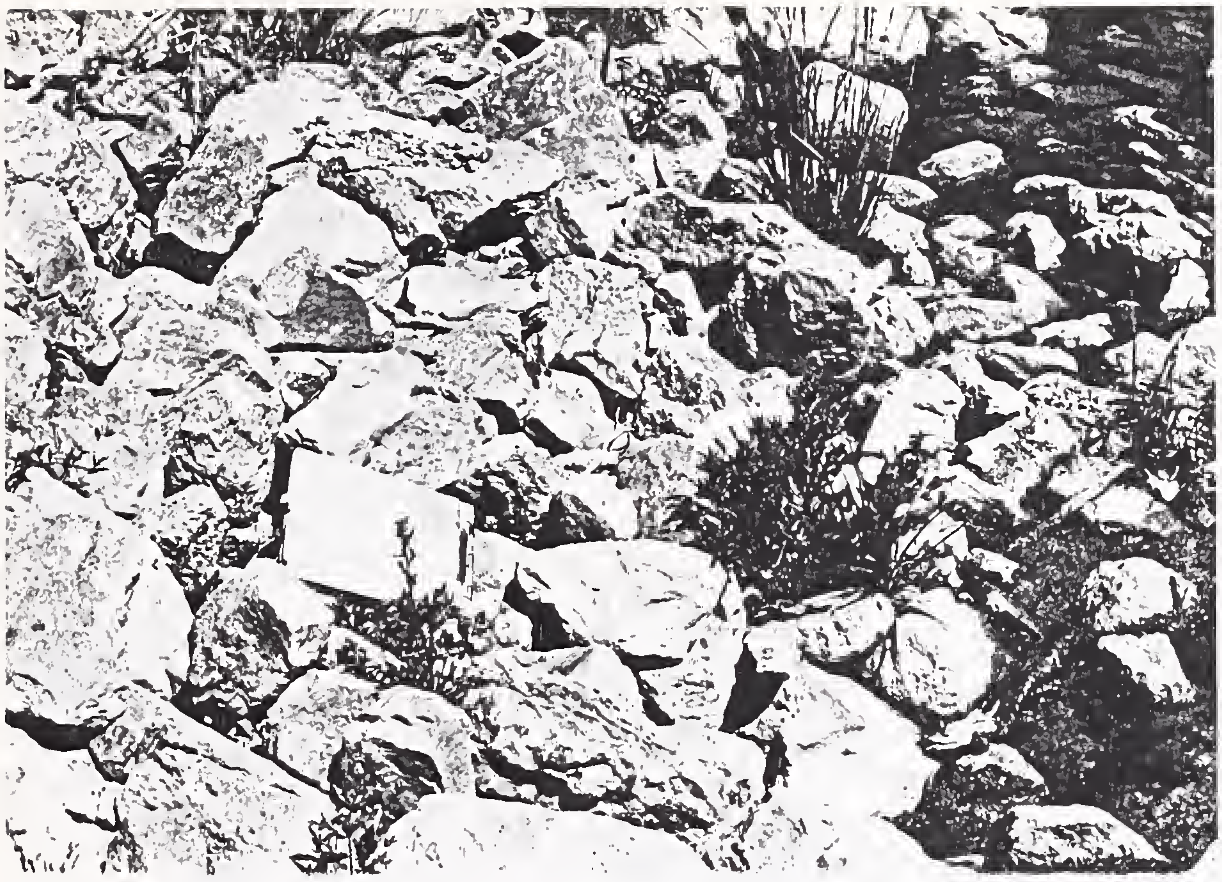


PHOTO NO. 3 - Rock riprap on upstream face. Classification: calcarious sandstone and limestone.

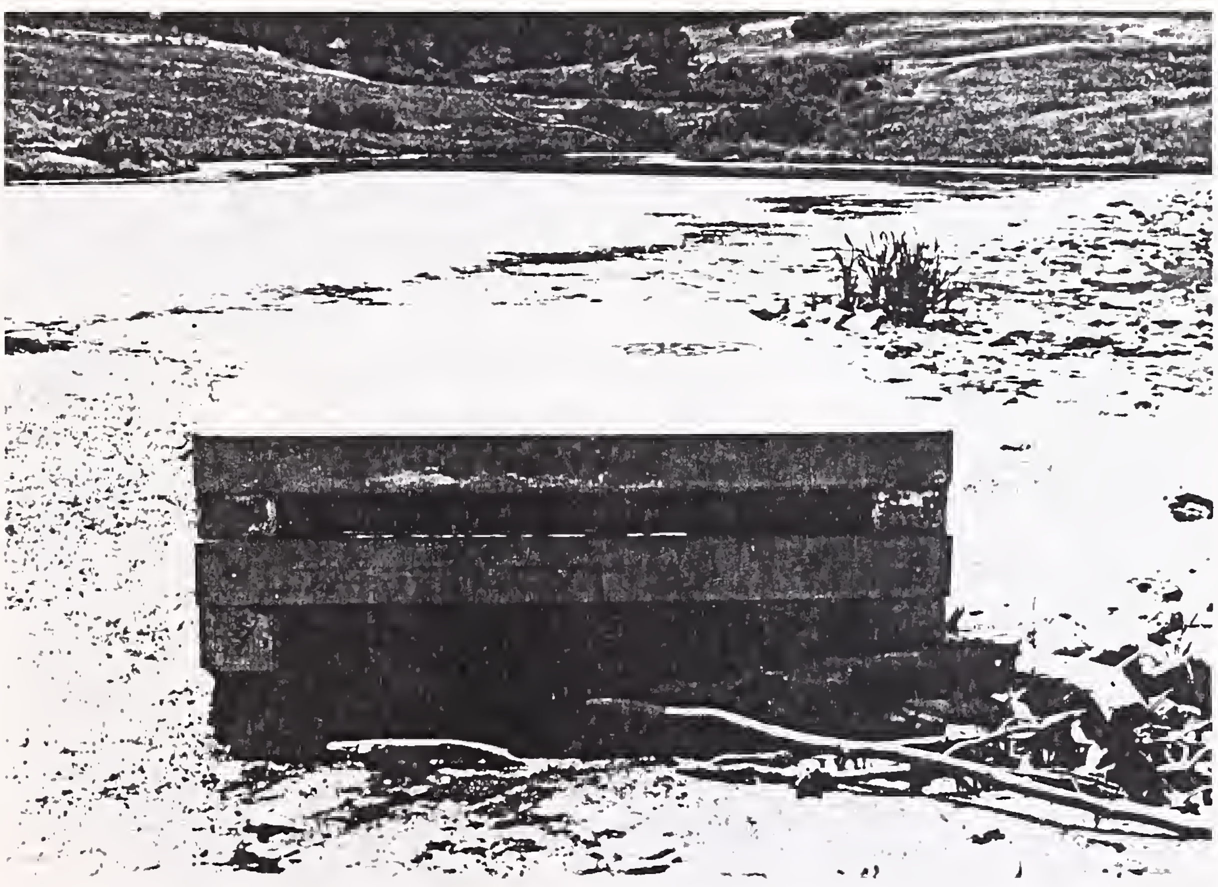


PHOTO NO. 4 - Principal spillway, two-sided inlet with cover. Notice debris accumulation. Emergency spillway inlet in upper right corner of picture.

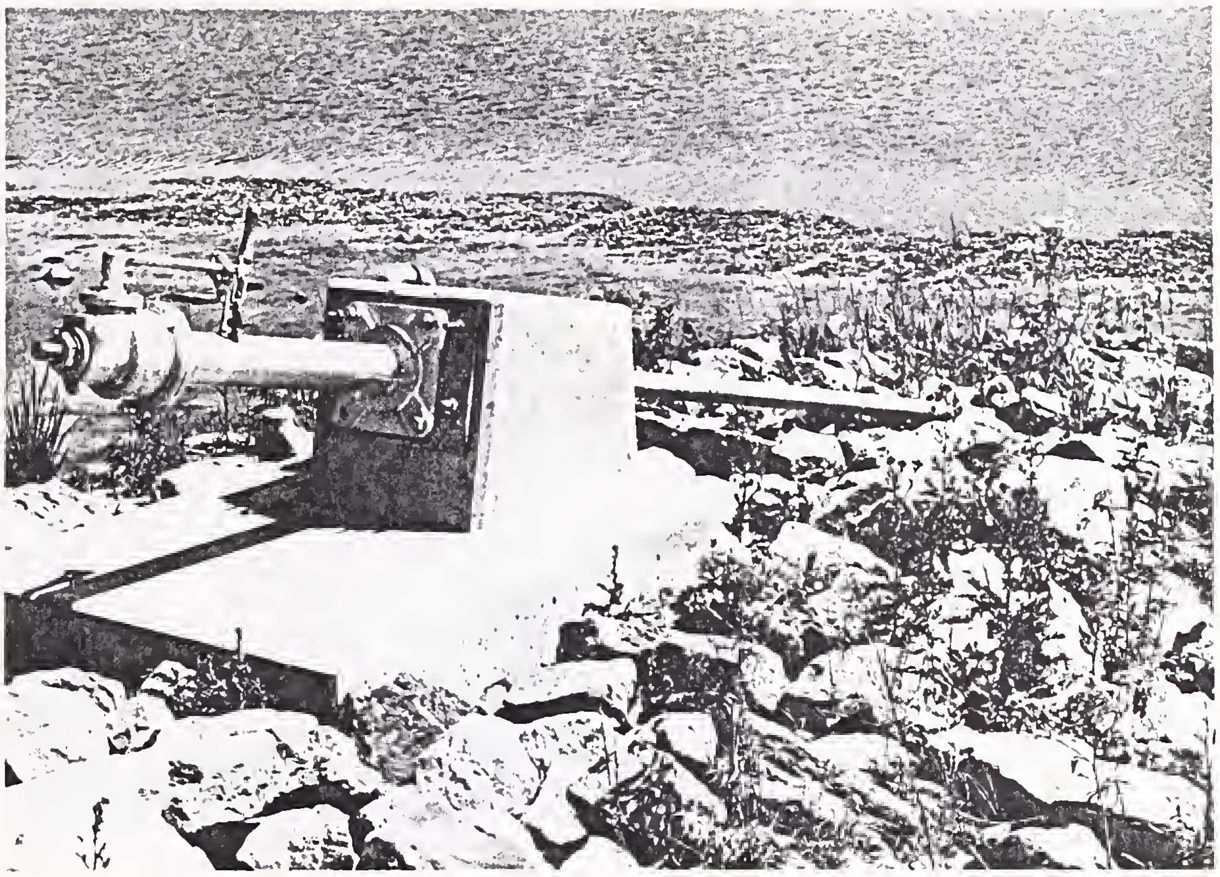


PHOTO NO. 5 - Manual operator for low-level outlet. Also shown are the gate stem, air vent, and concrete pedestal.

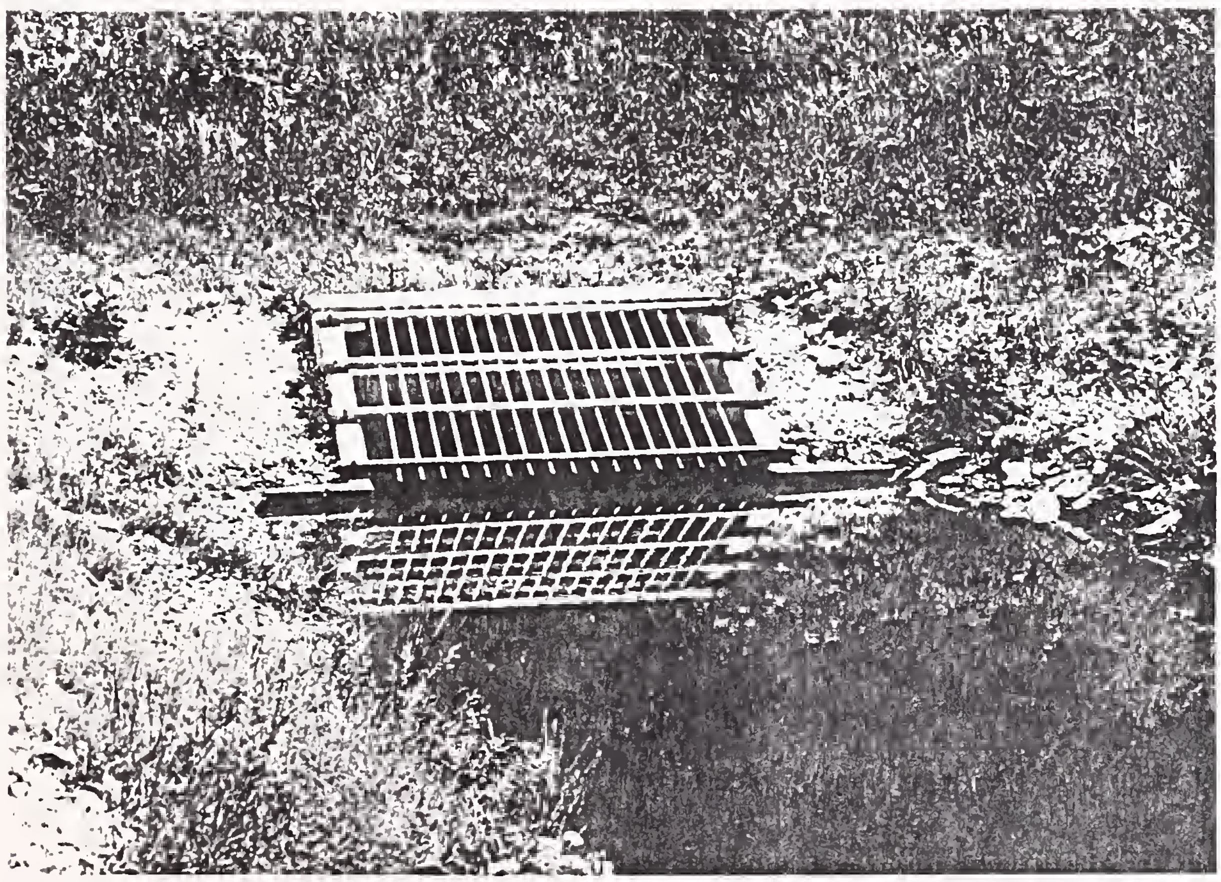


PHOTO NO. 6 - Outlet structure. Standing on right bank looking upstream at outlet structure/energy dissipator.

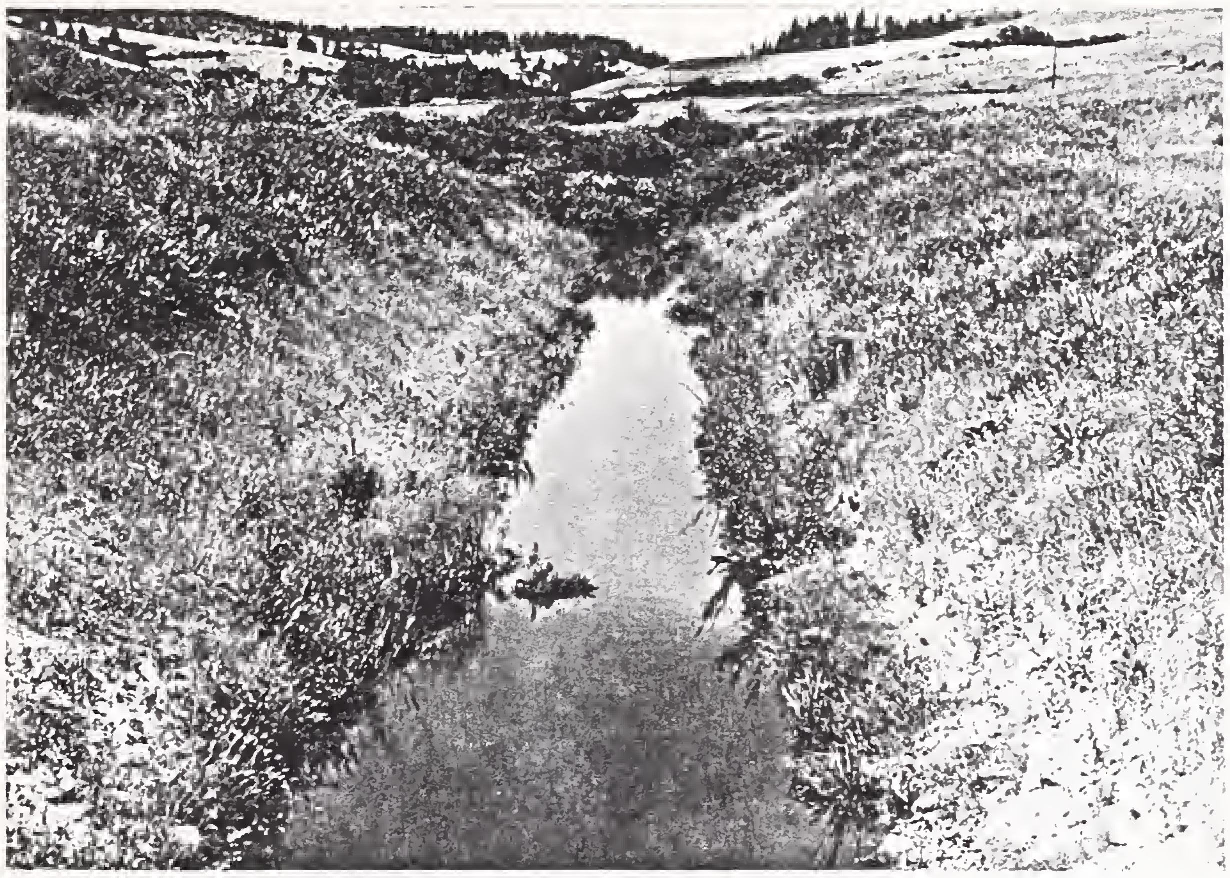


PHOTO NO. 7 - Hanson Creek return channel. Standing on outlet structure looking downstream.

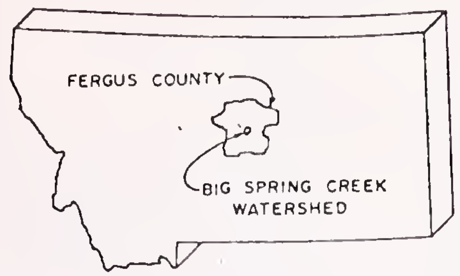
APPENDIX D

HANSON CREEK DAM

PROJECT DRAWINGS

Exhibit D1	Construction Plans
Exhibit D2	Dam Crest Profile (Aug. 1979)
Exhibit D3	Measured Embankment Slopes (July, 1979)
Exhibit D4	Soils Design Data

HANSON



LOCATION MAP

EXHIBIT D1

BIG SPRING CREEK WATERSHED PROTECTION, FLOOD PREVENTION AND RECREATION PROJECT

FERGUS COUNTY, MONTANA

PLANS FOR THE CONSTRUCTION OF HANSON CREEK DAM

PREPARED BY

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

INDEX OF DRAWINGS

SHT. NO.	TITLE
1.	INDEX OF DRAWINGS
2.	GENERAL LAYOUT, LOCATION AND DRAINAGE AREA MAPS
3.	PLAN OF DAM
4.	FOUNDATION PLAN AND PROFILE
5.	TYPICAL CROSS SECTIONS OF DAM
6.	TYPICAL CROSS SECTIONS OF DAM
7.	DRAINAGE DETAILS
8.	PLAN-PROFILE OF EMERGENCY SPILLWAY
9.	TYPICAL CROSS SECTIONS OF EMERGENCY SPILLWAY
10.	BORING LOGS
11.	PLAN-PROFILE OF PRINCIPAL SPILLWAY
12.	PLAN-PROFILE OF PRINCIPAL SPILLWAY
13.	DRAWDOWN INLET STRUCTURE DETAILS
14.	GATE CONTROL DETAILS
15	RISER DETAILS
16.	RISER REINFORCEMENT DETAILS
17.	RISER REINFORCEMENT DETAILS
18.	CRADLE AND ANTI-SEEP COLLAR DETAILS
19.	PRINCIPAL SPILLWAY OUTLET STRUCTURE DETAILS
20.	PRINCIPAL SPILLWAY OUTLET STRUCTURE SAFETY COVER DETAILS
21.	STRUCTURE PAY LIMITS

STRUCTURAL NOTES

1. All exposed concrete edges shall be chamfered 3/4 inch.
2. Indicated reinforcing bar spacing is center to center of bars. Bar cover is clear distance between surface of bar and face of concrete, and shall be 2 inches for formed and top surfaces, and 3 inches for surfaces poured against earth, unless otherwise shown.
3. In sections having a single mat of reinforcing, the steel shall be positioned in the center of the section unless otherwise shown.
4. All bar splices not shown on the drawings shall be staggered with bars lapping a minimum of 30 bar diameters of the smaller bar being spliced.
5. All bar bending dimensions are out to out of the bar.
6. All concrete shall be Class 4,000 X (4,000 p.s.i. compressive strength at 28 days).

GENERAL NOTES

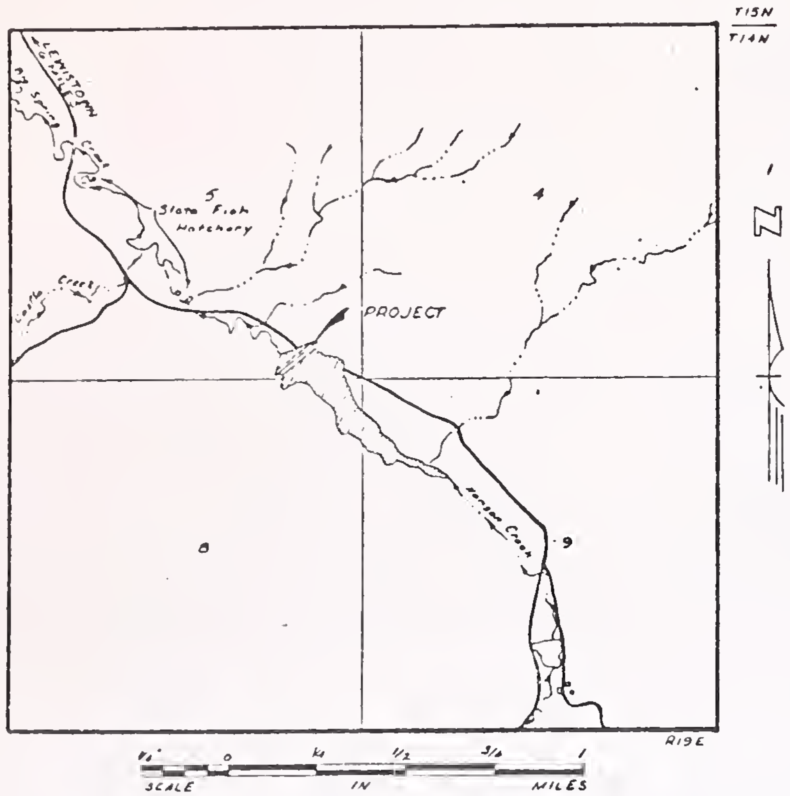
1. Elevations are in feet above mean sea level.
2. All stationing refers to centerline (℄) of construction and is measured horizontal distance.
3. Quantities are for bid purposes only. Contractor will be responsible for the furnishing and placing of all materials.
4. All logs of soils exploration are abridged. Complete investigation logs and laboratory test reports are available for reference at the City Clerk's office at Lewistown, Montana.

NOTE: These Sheets are not "as built" drawings; however some "as built" information has been provided on certain drawings/details.

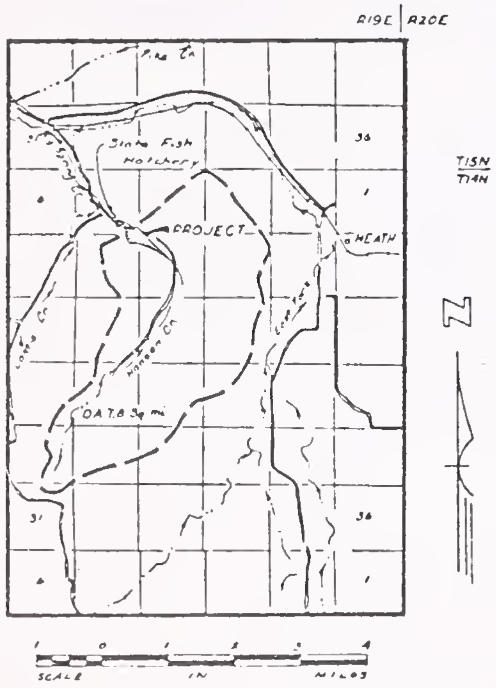
sheet 1

INDEX OF DRAWINGS BIG SPRING CREEK WATERSHED FERGUS COUNTY, MONTANA	
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	
R.S.-D.W.-J.K.	5-72
V.B.L.	5-72
R.S. P.J.V.	7-E-22249

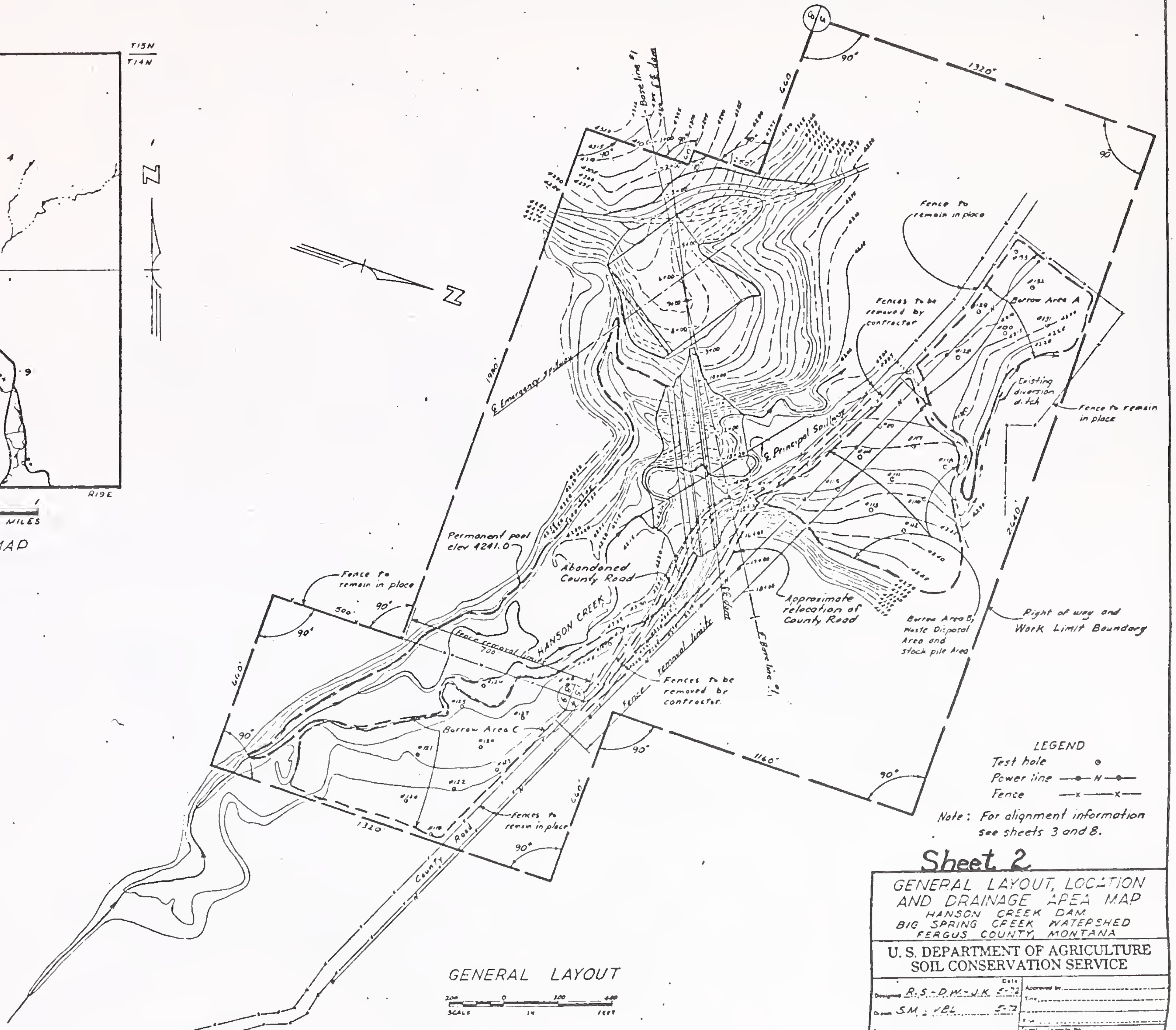
APPROVED BY [signature] DATE: 5-2-72



GENERAL LOCATION MAP



DRAINAGE AREA MAP



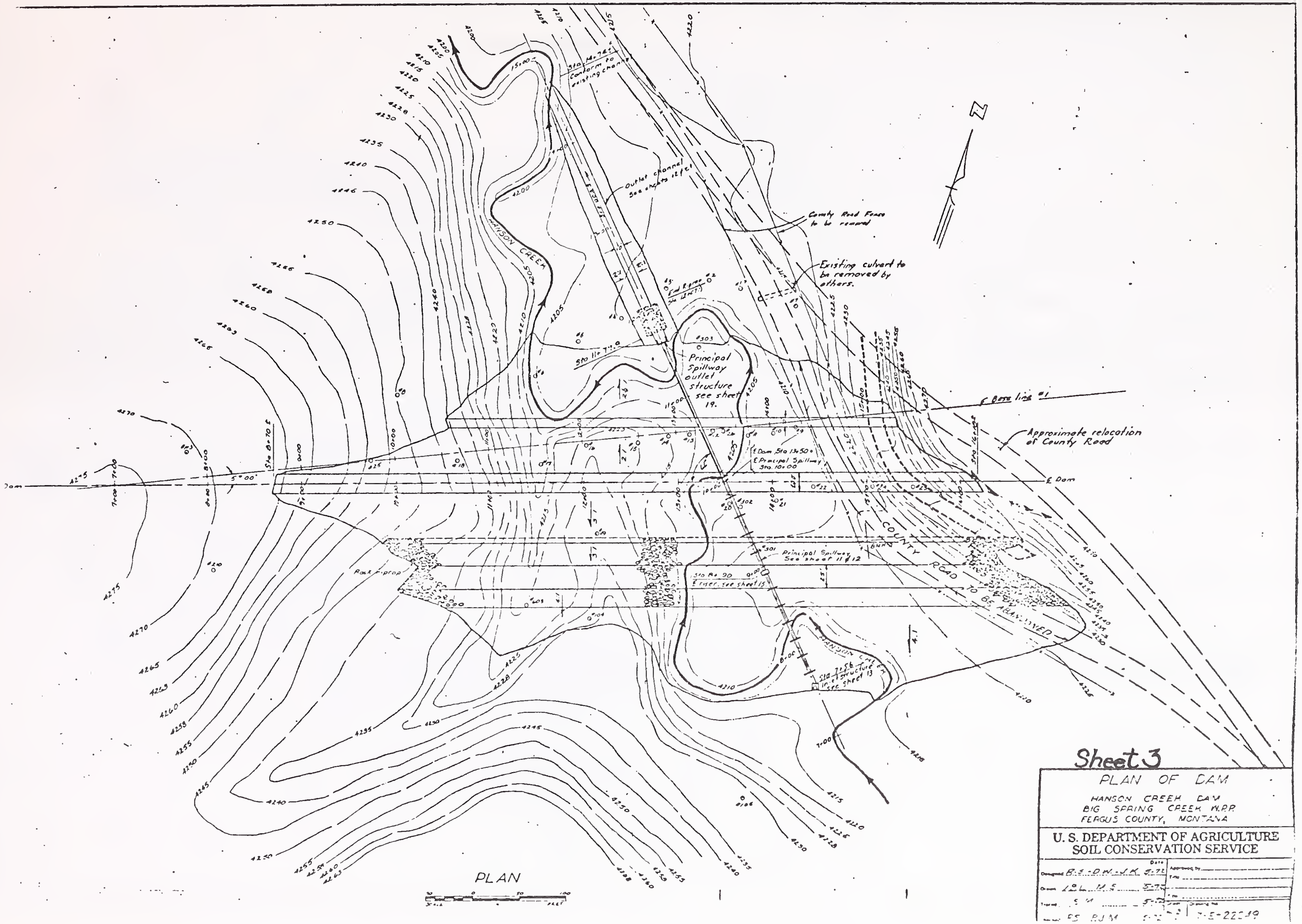
GENERAL LAYOUT

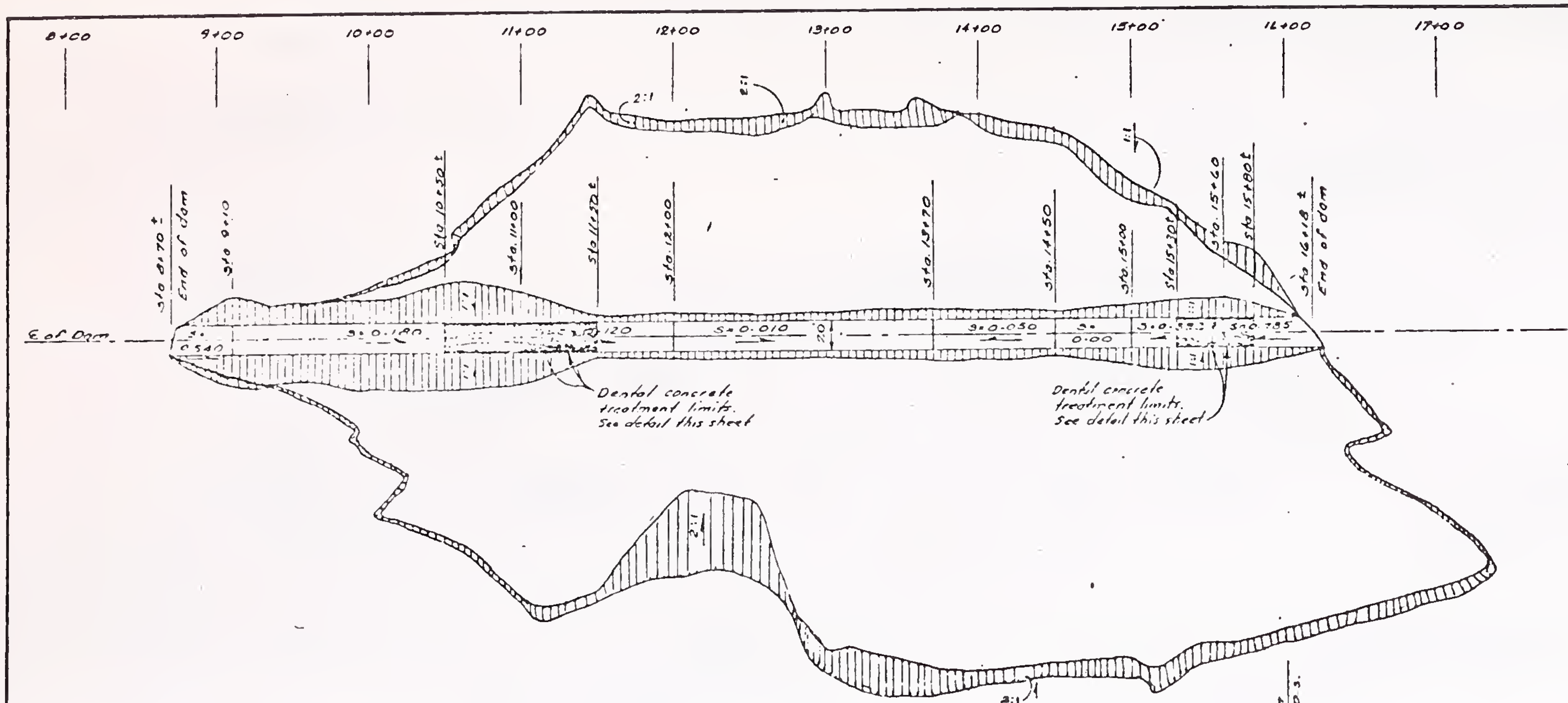
Sheet 2

GENERAL LAYOUT, LOCATION AND DRAINAGE AREA MAP
HANSON CREEK DAM
BIG SPRING CREEK WATERSHED
FERGUS COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

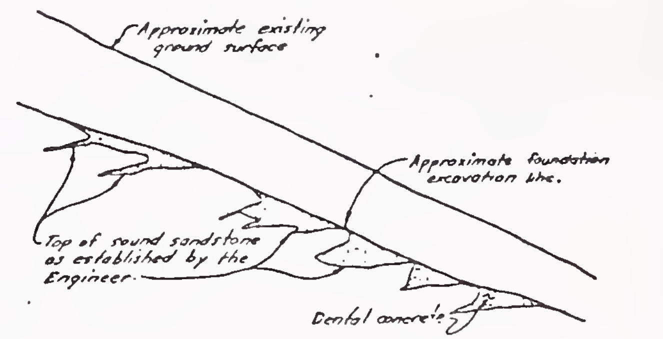
		Date	
Designed	R.S.-D.W.-J.K.	5-72	Approved by
Drawn	S.M.; V.B.L.	5-72	Title
Traced			Title
Checked	R.S., F.J.M.	5-7	Sheet 2 of 21 · Drawing No. 7-E-22249


Sheet 3
PLAN OF DAM
HANSON CREEK DAM
BIG SPRING CREEK W.P.P.
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PLAN
HANSON CREEK
Outlet channel See sheets 12 & 21
County Road Fence to be moved
Existing culvert to be removed by others.
Principal Spillway outlet structure see sheet 19.
Approximate relocation of County Road
Principal Spillway See sheet 11 & 12
COUNTY ROAD TO BE ABANDONED
Rock riprap
℄ Dam
℄ Base line #1
7-E-22019



FOUNDATION PLAN

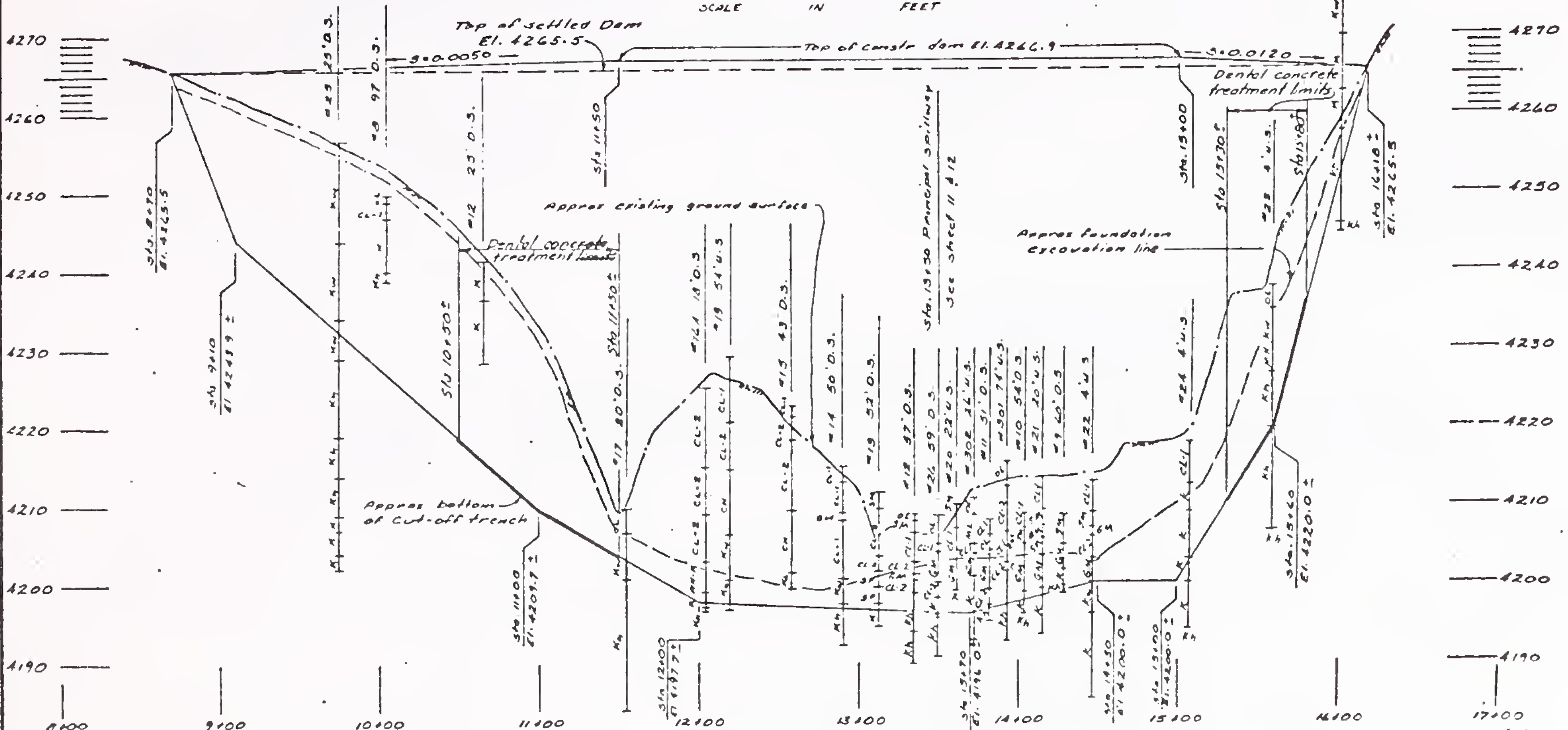
SCALE IN FEET



STA 10+50 ± TO STA 11+50 ±

STA 15 + 30 ± TO STA 15 + 80 ±

DENTAL CONCRETE TREATMENT DETAILS



CENTERLINE PROFILE OF DAM

Notes:

1. Grades as shown are for initial staking. Final extent of excavation will be determined in the field by the Engineer.
2. See sheet 10 for boring legend.
3. Boring logs shown on this sheet are also shown on sheet 10.
4. All logs are abridged and are shown for bidders information. Complete field logs, geology report, and laboratory test reports are available for prospective bidders study at the City Clerks Office at Lewistown, Montana.

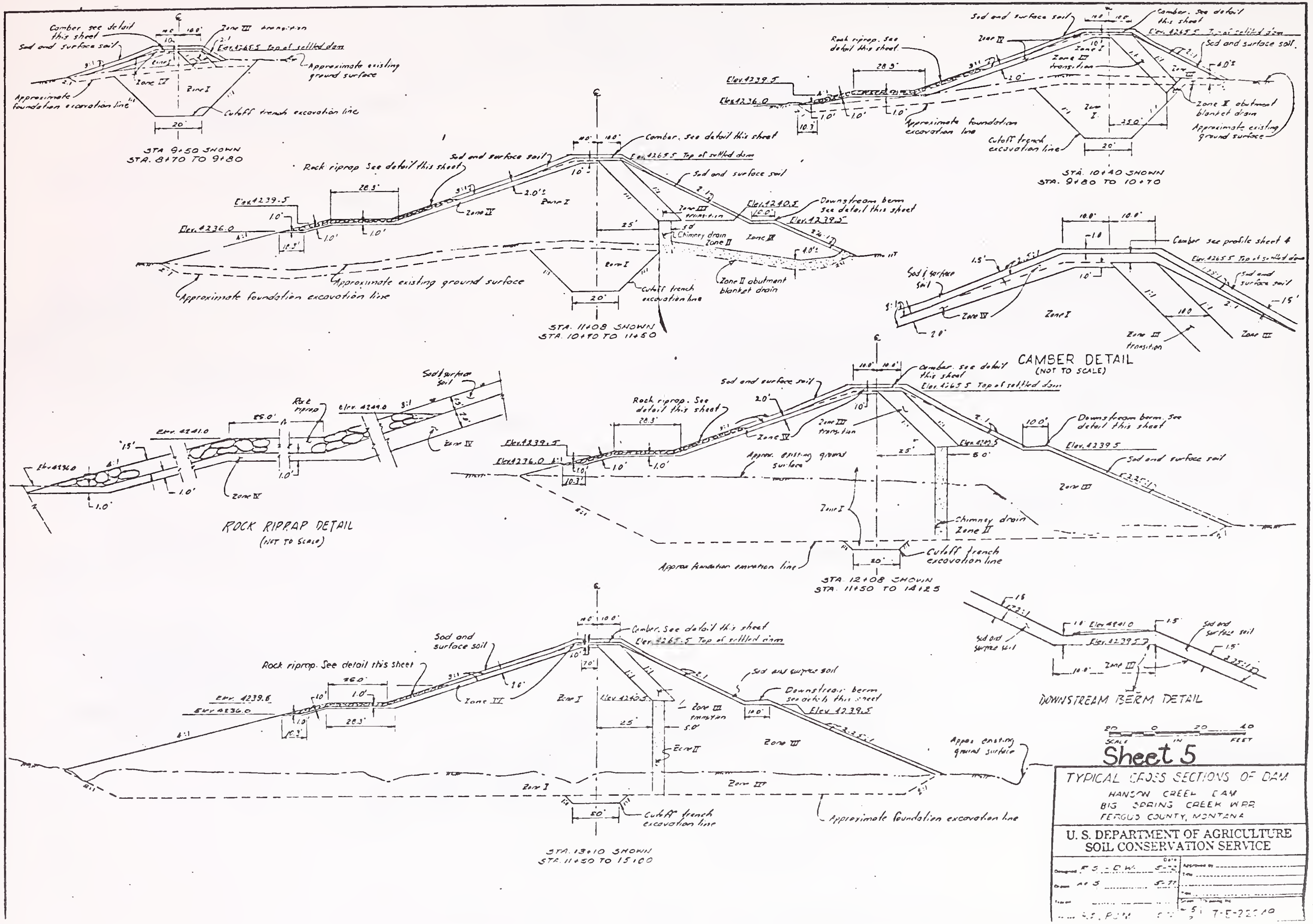
Sheet 4

FOUNDATION
PLAN AND PROFILE
HANSON CREEK DAM
BIG SPRING CREEK W.P.P.
FERGUS COUNTY, MONTANA

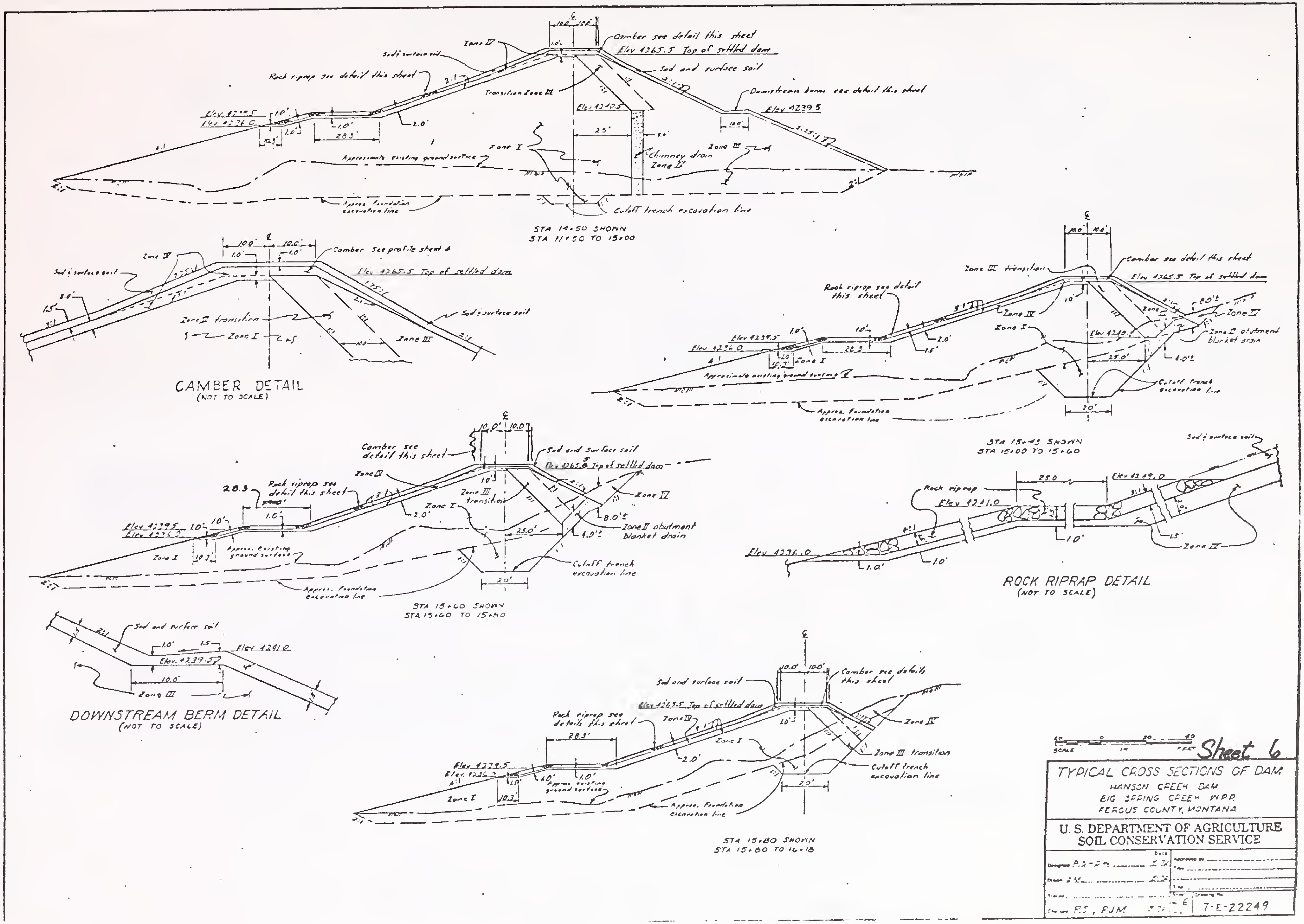
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

R.S.-O.W.-J.K. 5-72
M.J. 5-72
R.S. PJM. 5-72

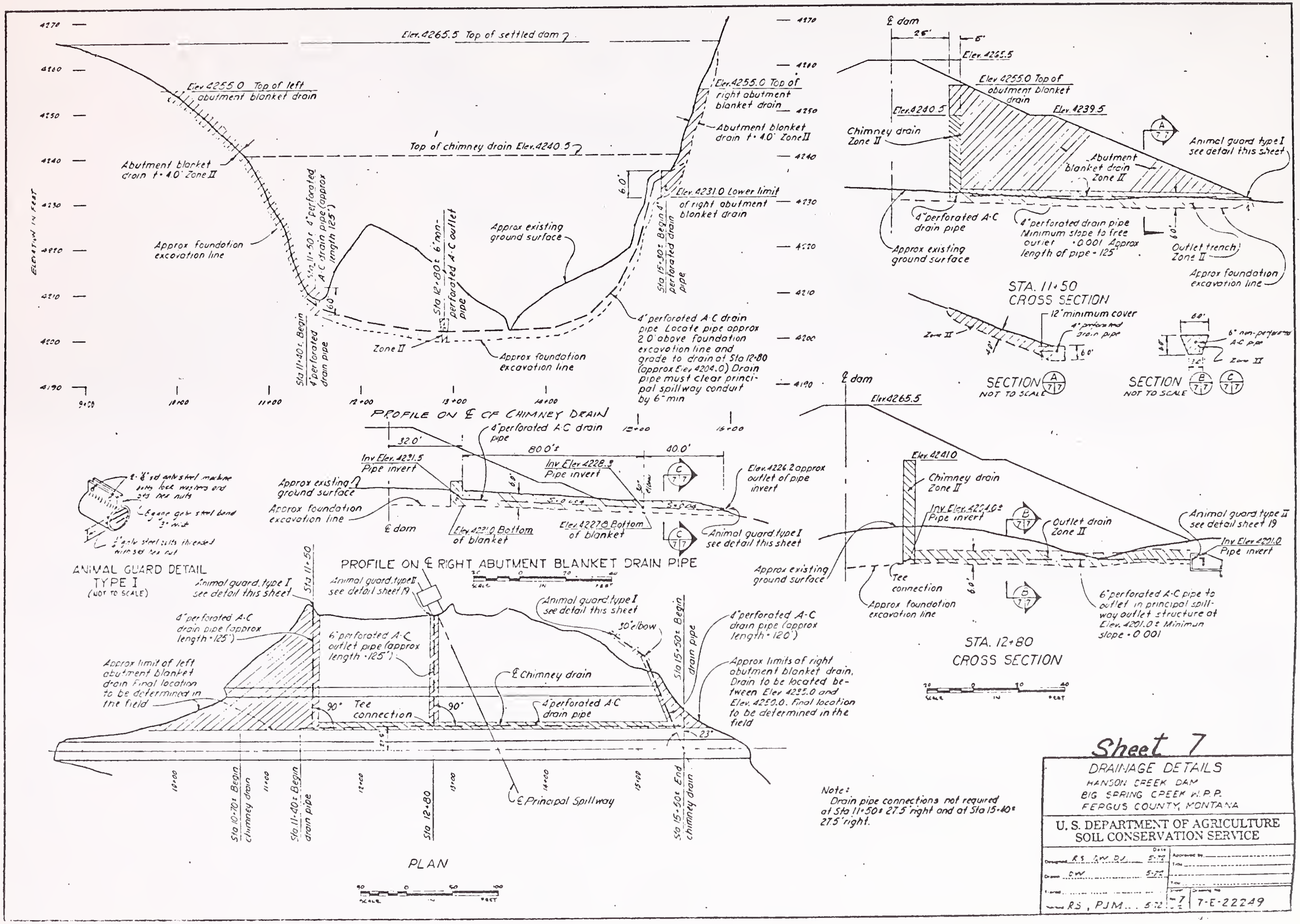
7-E-22249

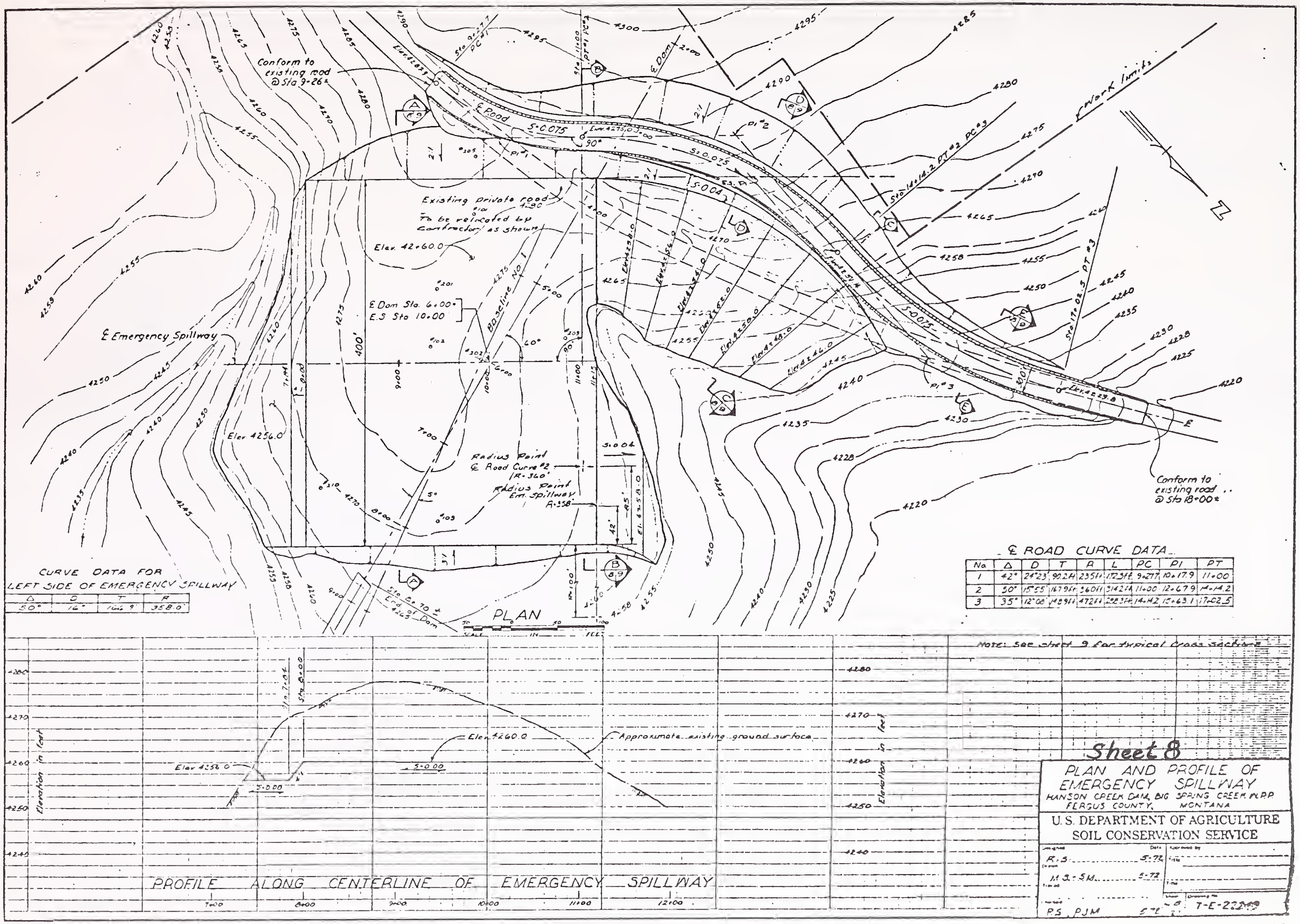


STA 9+50 SHOWN
STA. 8+70 TO 9+80
STA. 10+40 SHOWN
STA. 9+80 TO 10+70
STA. 11+08 SHOWN
STA. 10+70 TO 11+50
CAMBER DETAIL
(NOT TO SCALE)
ROCK RIPRAP DETAIL
(NOT TO SCALE)
STA. 12+08 SHOWN
STA. 11+50 TO 14+25
DOWNSTREAM BERM DETAIL
STA. 13+10 SHOWN
STA. 11+50 TO 15+00
Camber. See detail this sheet
Elev. 4265.5 Top of settled dam
Sod and surface soil
Rock riprap. See detail this sheet
Downstream berm. See detail this sheet
Chimney drain Zone II
Zone II abutment blanket drain
Cutoff trench excavation line
Approximate existing ground surface
Approximate foundation excavation line
Camber see profile sheet 4
Sheet 5
TYPICAL CROSS SECTIONS OF DAM
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE



STA 14+50 SHOWN
STA 11+50 TO 15+00
Camber see detail this sheet
Elev 4265.5 Top of settled dam
Sod and surface soil
Downstream berm see detail this sheet
Elev 4239.5
Rock riprap see detail this sheet
Transition Zone III
Elev 4240.5
Chimney drain Zone II
Cutoff trench excavation line
Approximate existing ground surface
Approx. Foundation excavation line
CAMBER DETAIL
(NOT TO SCALE)
Camber See profile sheet 4
STA 15+43 SHOWN
STA 15+00 TO 15+60
Zone II abutment blanket drain
STA 15+60 SHOWN
STA 15+60 TO 15+80
ROCK RIPRAP DETAIL
(NOT TO SCALE)
Rock riprap
Elev 4241.0
Elev 4236.0
DOWNSTREAM BERM DETAIL
(NOT TO SCALE)
Elev. 4239.5
STA 15+80 SHOWN
STA 15+80 TO 16+18
Zone III transition
Sheet 6
TYPICAL CROSS SECTIONS OF DAM
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249


Elev. 4265.5 Top of settled dam
Elev 4255.0 Top of left abutment blanket drain
Top of chimney drain Elev. 4240.5
Abutment blanket drain t = 4.0' Zone II
Elev. 4255.0 Top of right abutment blanket drain
Elev. 4231.0 Lower limit of right abutment blanket drain
Approx foundation excavation line
Approx existing ground surface
Sta 11+50± 4" perforated A-C drain pipe (approx length 125')
Sta 12+80± 6" non-perforated A-C outlet pipe
Sta 15+50± Begin 4" perforated drain pipe
Sta 11+40± Begin 4" perforated drain pipe
Zone II
4" perforated A-C drain pipe. Locate pipe approx 2.0' above foundation excavation line and grade to drain at Sta 12+80 (approx Elev 4204.0) Drain pipe must clear principal spillway conduit by 6" min
ELEVATION IN FEET
PROFILE ON ℄ OF CHIMNEY DRAIN
℄ dam
Elev. 4265.5
Elev. 4255.0 Top of abutment blanket drain
Elev. 4240.5
Elev. 4239.5
Chimney drain Zone II
Abutment blanket drain Zone II
Animal guard type I see detail this sheet
4" perforated A-C drain pipe
4" perforated drain pipe Minimum slope to free outlet = 0.001 Approx length of pipe = 125'
Outlet trench Zone II
STA. 11+50 CROSS SECTION
12" minimum cover
SECTION A/7 NOT TO SCALE
SECTION B/7 C/7 NOT TO SCALE
6" non-perforated A-C pipe
Inv Elev. 4231.5 Pipe invert
Inv Elev. 4228.3 Pipe invert
Elev. 4226.2 approx outlet of pipe invert
Elev. 4231.0 Bottom of blanket
Elev. 4227.8 Bottom of blanket
Animal guard type I see detail this sheet
PROFILE ON ℄ RIGHT ABUTMENT BLANKET DRAIN PIPE
ANIMAL GUARD DETAIL TYPE I (NOT TO SCALE)
Elev. 4241.0
Inv Elev. 4204.0± Pipe invert
Outlet drain Zone II
Animal guard type II see detail sheet 19
Inv Elev 4201.0 Pipe invert
Tee connection
6" perforated A-C pipe to outlet in principal spillway outlet structure at Elev. 4201.0± Minimum slope = 0.001
STA. 12+80 CROSS SECTION
Animal guard type II see detail sheet 19
4" perforated A-C drain pipe (approx length = 125')
6" perforated A-C outlet pipe (approx length = 125')
30° elbow
4" perforated A-C drain pipe (approx length = 120')
Approx limit of left abutment blanket drain. Final location to be determined in the field
Approx limits of right abutment blanket drain. Drain to be located between Elev 4235.0 and Elev. 4250.0. Final location to be determined in the field
℄ Chimney drain
℄ Principal Spillway
Sta 10+70± Begin chimney drain
Sta 11+40± Begin drain pipe
Sta 12+80
Sta 15+50± Begin drain pipe
Sta 15+50± End chimney drain
PLAN
Note: Drain pipe connections not required at Sta 11+50± 27.5' right and at Sta 15+40± 27.5' right.
Sheet 7
DRAINAGE DETAILS
HANSON CREEK DAM
BIG SPRING CREEK W.P.P.
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249

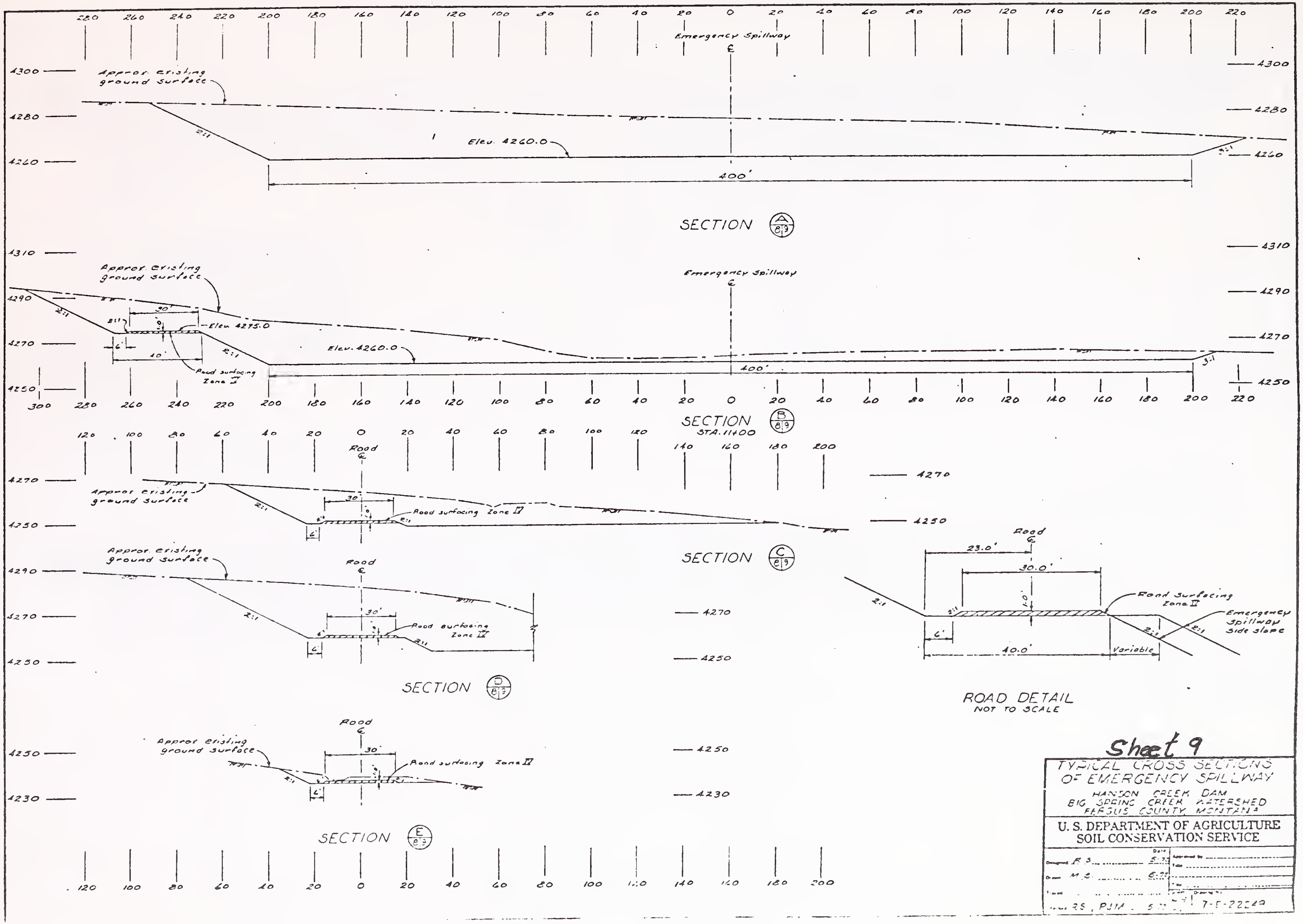


CURVE DATA FOR LEFT SIDE OF EMERGENCY SPILLWAY

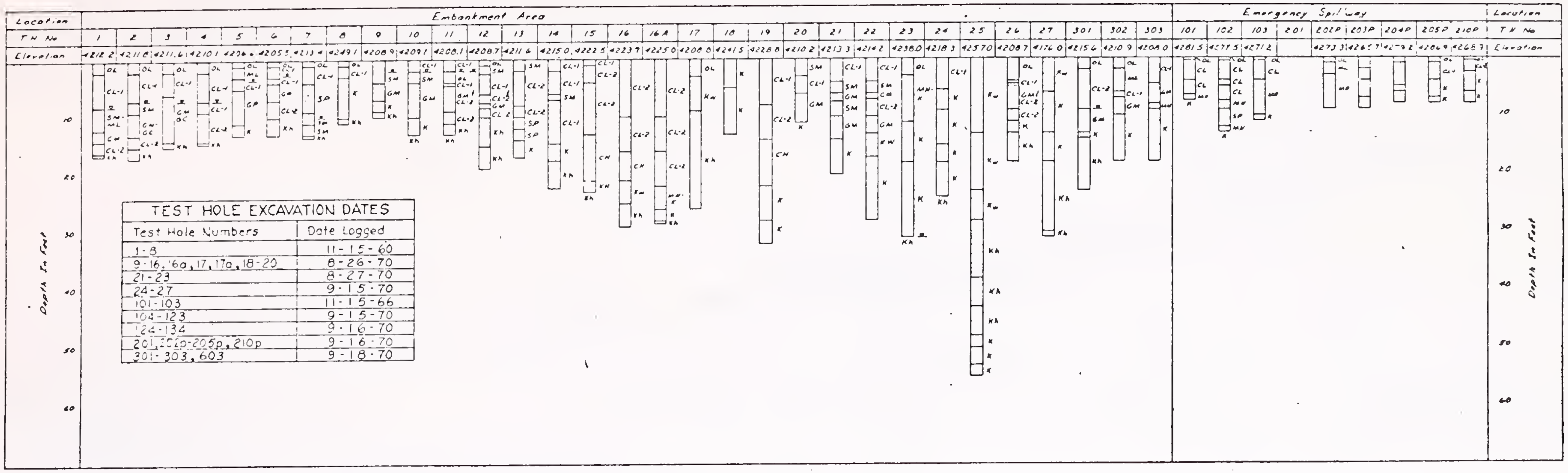
Δ	D	T	R
50°	16°	166.9'	358.0'

℄ ROAD CURVE DATA

No.	Δ	D	T	R	L	PC	PI	PT
1	42°	24°23'	90.2H	235.1H	172.3H	9+27.7	10+17.9	11+00
2	50°	15°55'	167.9H	360.1H	314.2H	11+00	12+67.9	14+14.2
3	35°	12°00'	149.9H	472.1H	298.3H	14+14.2	15+63.1	17+02.5


Emergency Spillway ℄
Approx. existing ground surface
Elev. 4260.0
400'
2:1
3:1
SECTION A 8|9
Emergency Spillway ℄
Elev. 4275.0
Road surfacing Zone II
30'
40'
6'
SECTION B 8|9 STA. 11+00
Road ℄
Road surfacing Zone II
SECTION C 8|9
SECTION D 8|9
SECTION E 8|9
23.0'
30.0'
1.0'
40.0'
Variable
Road Surfacing Zone II
Emergency Spillway Side Slope
ROAD DETAIL
NOT TO SCALE
Sheet 9
TYPICAL CROSS SECTIONS OF EMERGENCY SPILLWAY
HANSON CREEK DAM
BIG SPRING CREEK WATERSHED
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249

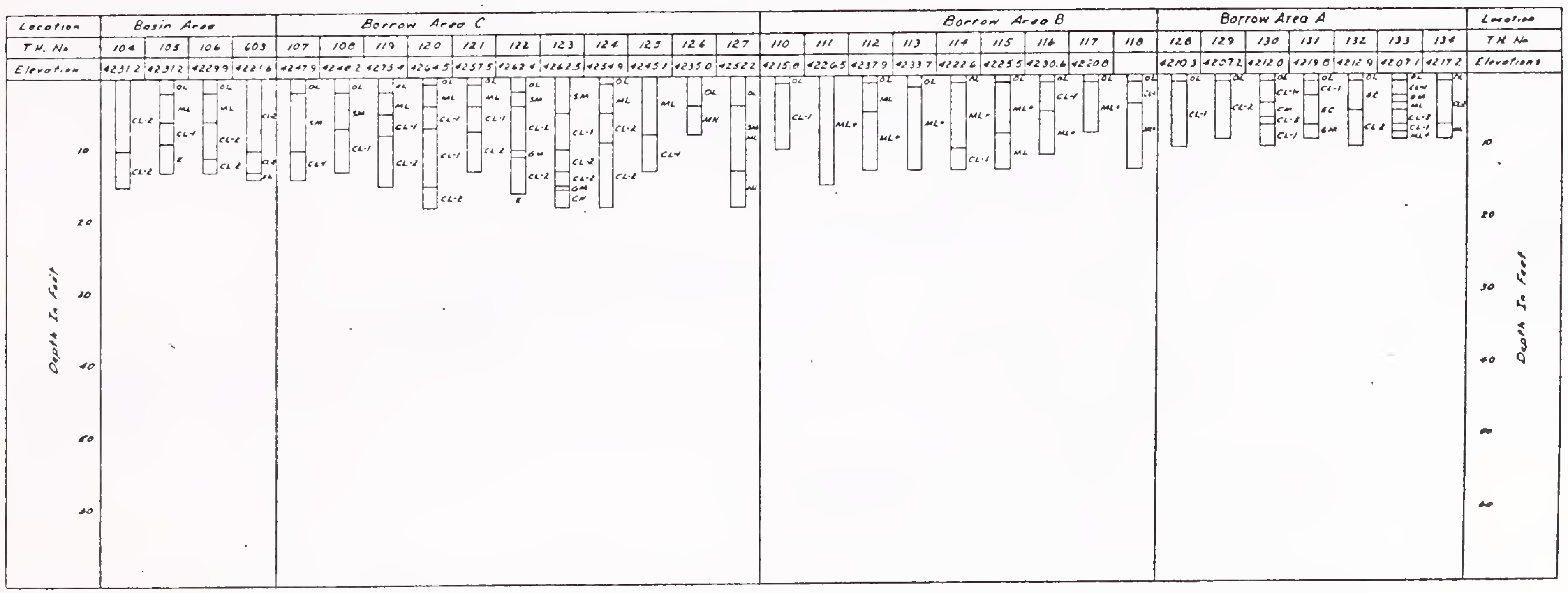
BORING LOGS



TEST HOLE EXCAVATION DATES

Test Hole Numbers	Date Logged
1-8	11-15-60
9-16, 16a, 17, 17a, 18-20	8-26-70
21-23	8-27-70
24-27	9-15-70
101-103	11-15-66
104-123	9-15-70
124-134	9-16-70
201, 202p-205p, 210p	9-16-70
301-303, 603	9-18-70

BORING LOGS



BORING LEGEND

- **CL** Clays of low to medium plasticity; silty sandy or gravely clays.
- **CL-1** Clays of low to medium plasticity.
- **CL-2** Clays of medium to high plasticity.
- **GM** Silty gravels.
- **SM** Silty sand.
- **SP** Poorly graded sands.
- **ML** Silts; silty, very fine sands sandy or clayey silts
- **Kw** Bedrock, weathered.
- **Kh** Bedrock, hard.
- **K** Bedrock
- **OL** Organic silts and organic silty clays of low liquid limits and low plasticity

Note: All logs are abridged and are shown for bidders information. Complete field logs, geology report, and laboratory test reports are available for prospective bidders study at the City Clerk's office at Lewistown, Montana.

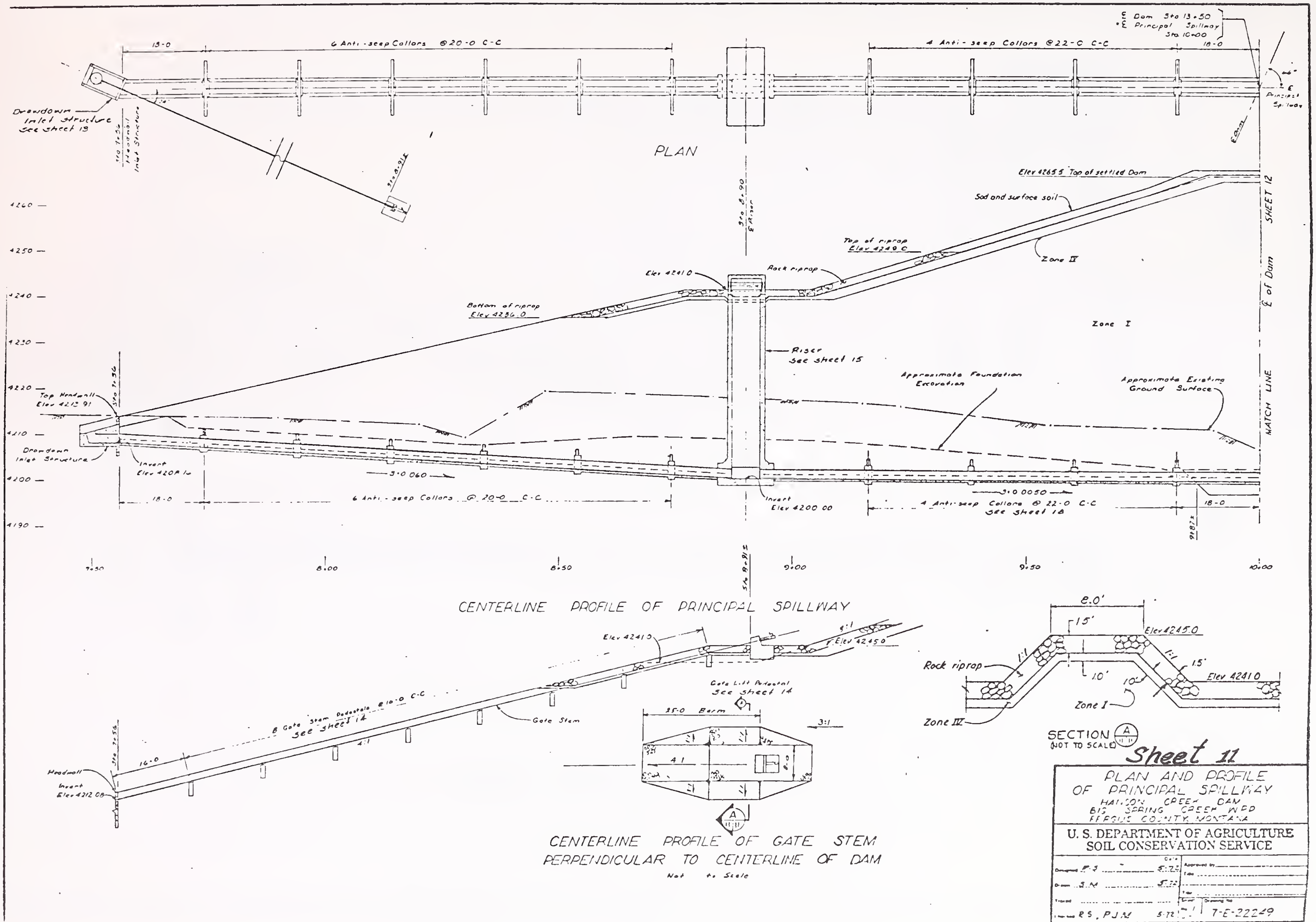
Sheet 10

BORING LOGS

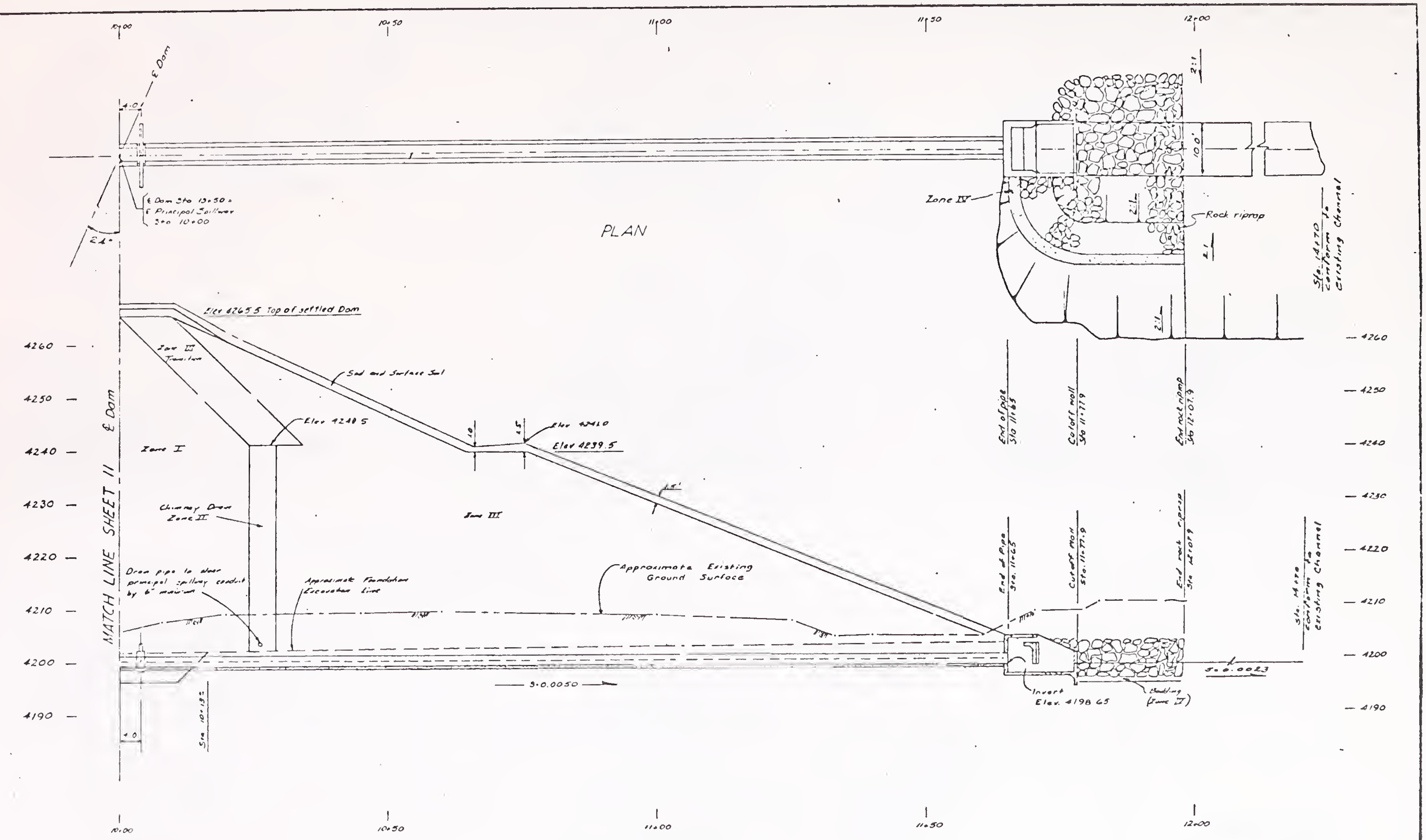
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
F. S.	5-72	
G.P.G. - J.L.C.	5-72	
R.S., P.J.M.	5-72	7-E-22249



PLAN
6 Anti-seep Collars @ 20-0 C-C
4 Anti-seep Collars @ 22-0 C-C
Dam Sta 13+50
Principal Spillway Sta 10+00
Drawdown Inlet Structure See sheet 13
CENTERLINE PROFILE OF PRINCIPAL SPILLWAY
Elev 4265.5 Top of settled Dam
Sod and surface soil
Top of riprap Elev 4249.0
Zone II
Rock riprap
Elev 4241.0
Bottom of riprap Elev 4236.0
Zone I
Riser See sheet 15
Approximate Foundation Excavation
Approximate Existing Ground Surface
Top Headwall Elev 4213.91
Drawdown Inlet Structure
Invert Elev 4208.16
Invert Elev 4200.00
4 Anti-seep Collars @ 22-0 C-C See sheet 18
6 Anti-seep Collars @ 20-0 C-C
SHEET 12
℄ of Dam
MATCH LINE
CENTERLINE PROFILE OF GATE STEM PERPENDICULAR TO CENTERLINE OF DAM
Not to Scale
Gate Lift Pedestal See sheet 14
8 Gate Stem Pedestals @ 10-0 C-C See sheet 14
Gate Stem
Headwall
Invert Elev 4212.08
25-0 Berm
SECTION A (NOT TO SCALE)
Rock riprap
Zone II
Zone I
Elev 4245.0
Elev 4241.0
Sheet 11
PLAN AND PROFILE OF PRINCIPAL SPILLWAY
HANSON CREEK DAM
BIG SPRING CREEK WPD
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249



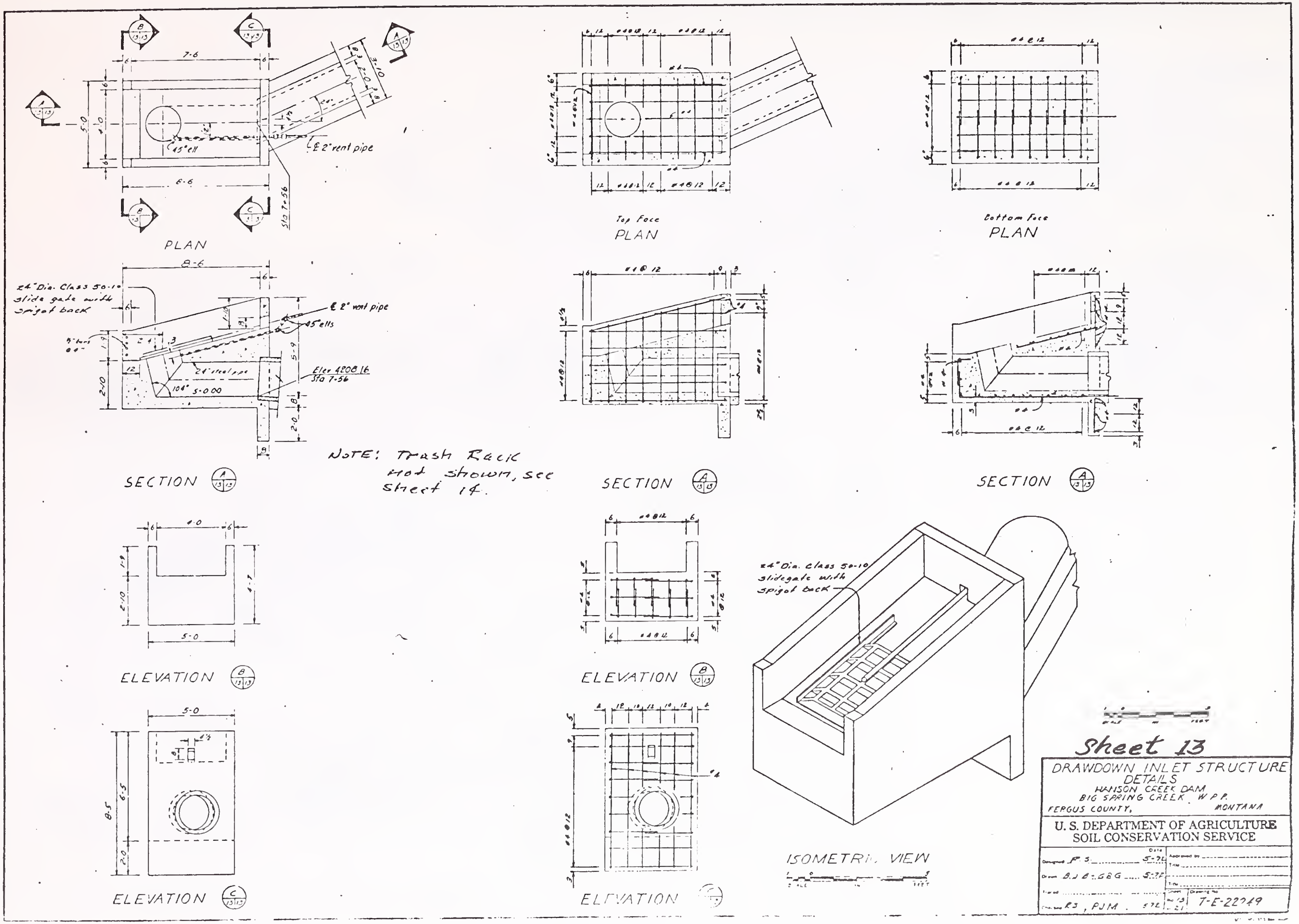
CENTERLINE PROFILE OF PRINCIPAL SPILLWAY

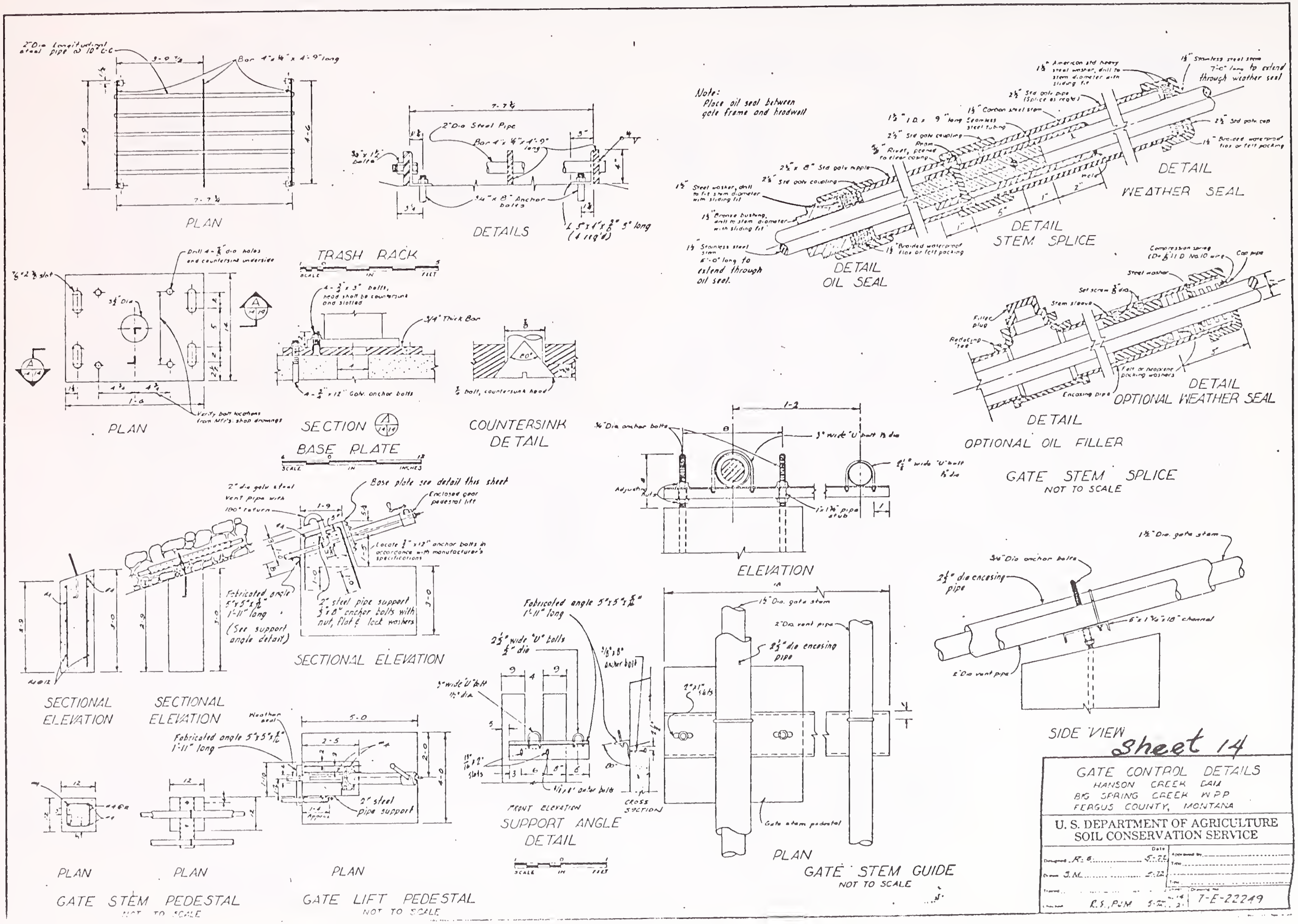
Sheet 12

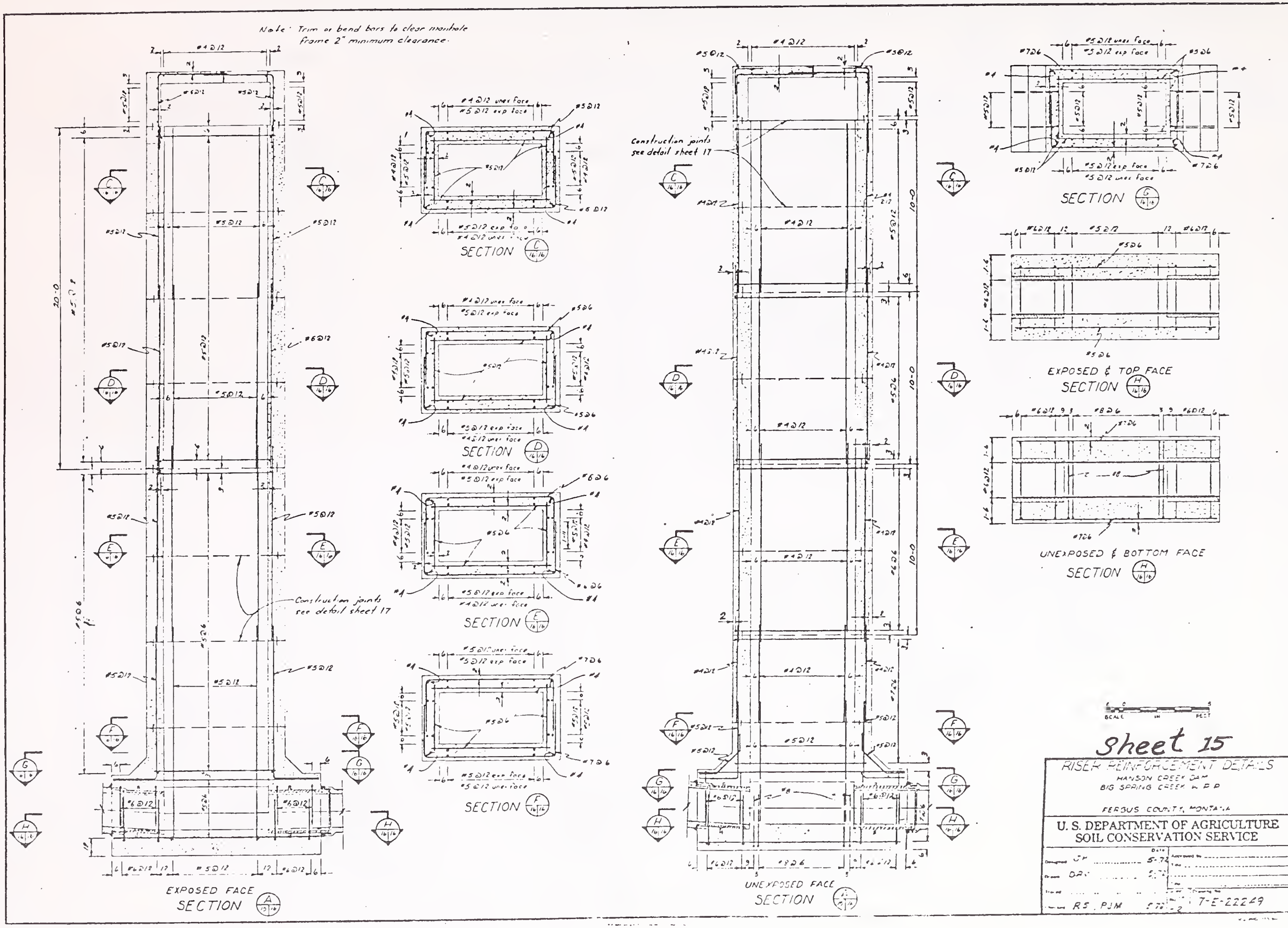
PLAN AND PROFILE OF PRINCIPAL SPILLWAY
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA

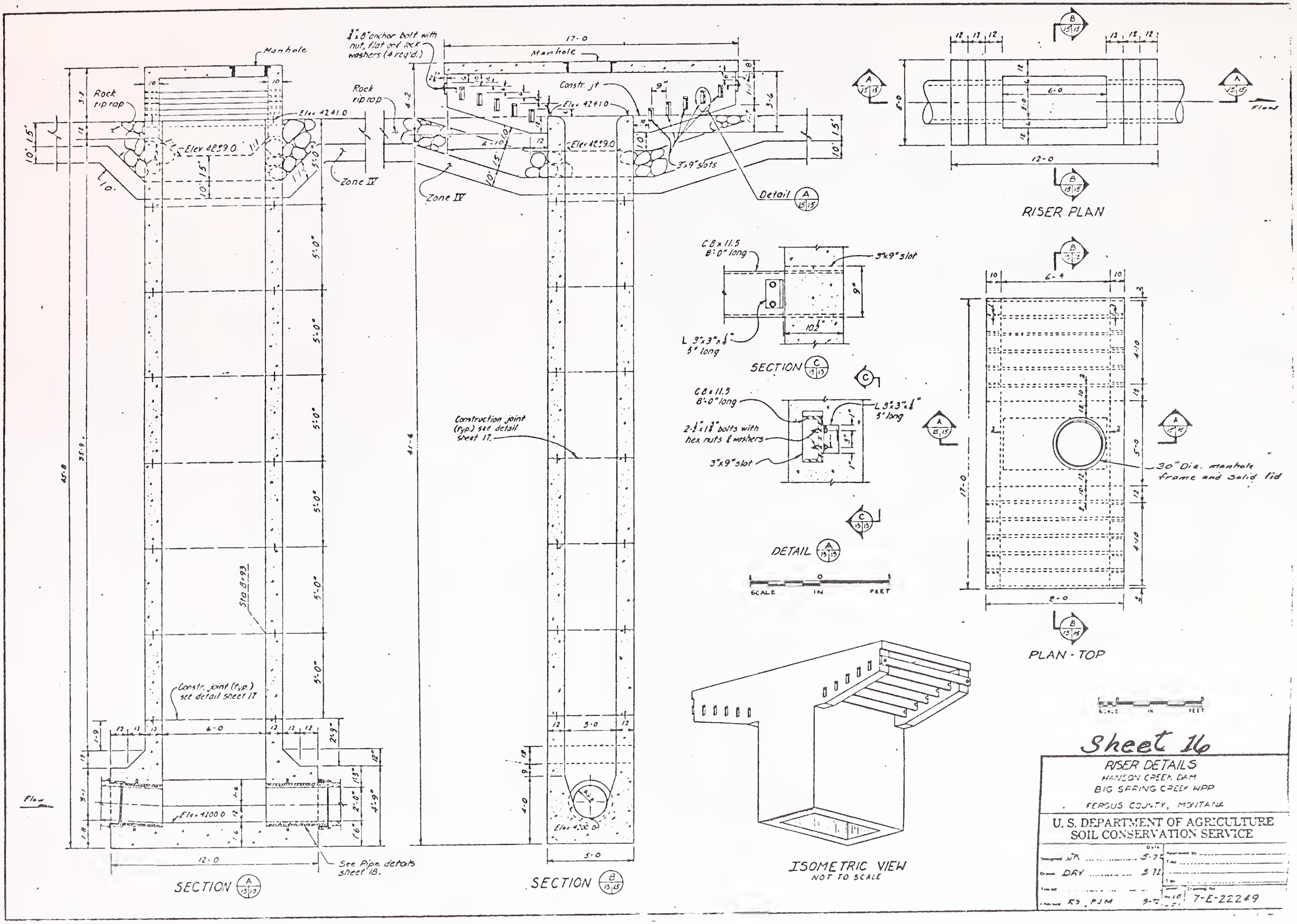
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed R.S.	5-73	Approved by	
Drawn S.M.	5-73	Title	
Traced		Sheet	Drawing No.
Checked RS, PJM, SK		2 of 2	7-E-22249

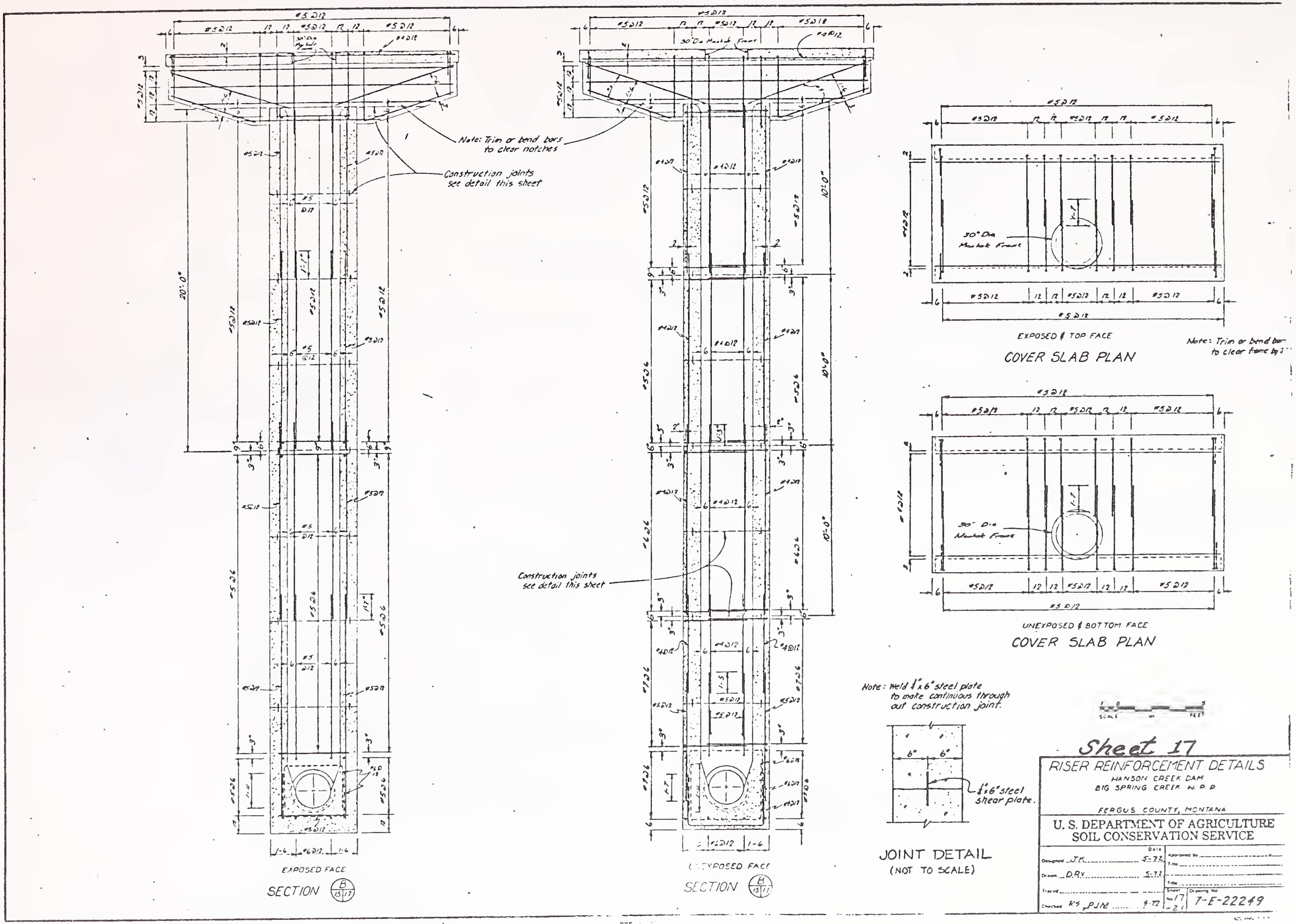

PLAN
Top Face
PLAN
Bottom Face
PLAN
24" Dia. Class 50-10 slide gate with spigot back
℄ 2" vent pipe
45° ells
24" steel pipe
Elev 4808.16
Sta 7+56
45° ell
℄ 2" vent pipe
Sta 7+56
SECTION A 13/13
SECTION A 13/13
SECTION A 13/13
NOTE: Trash Rack not shown, see Sheet 14.
ELEVATION B 13/13
ELEVATION B 13/13
ELEVATION C 13/13
ELEVATION
24" Dia. Class 50-10 slidegate with spigot back
ISOMETRIC VIEW
Sheet 13
DRAWDOWN INLET STRUCTURE DETAILS
HANSON CREEK DAM
BIG SPRING CREEK W.P.P.
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22749

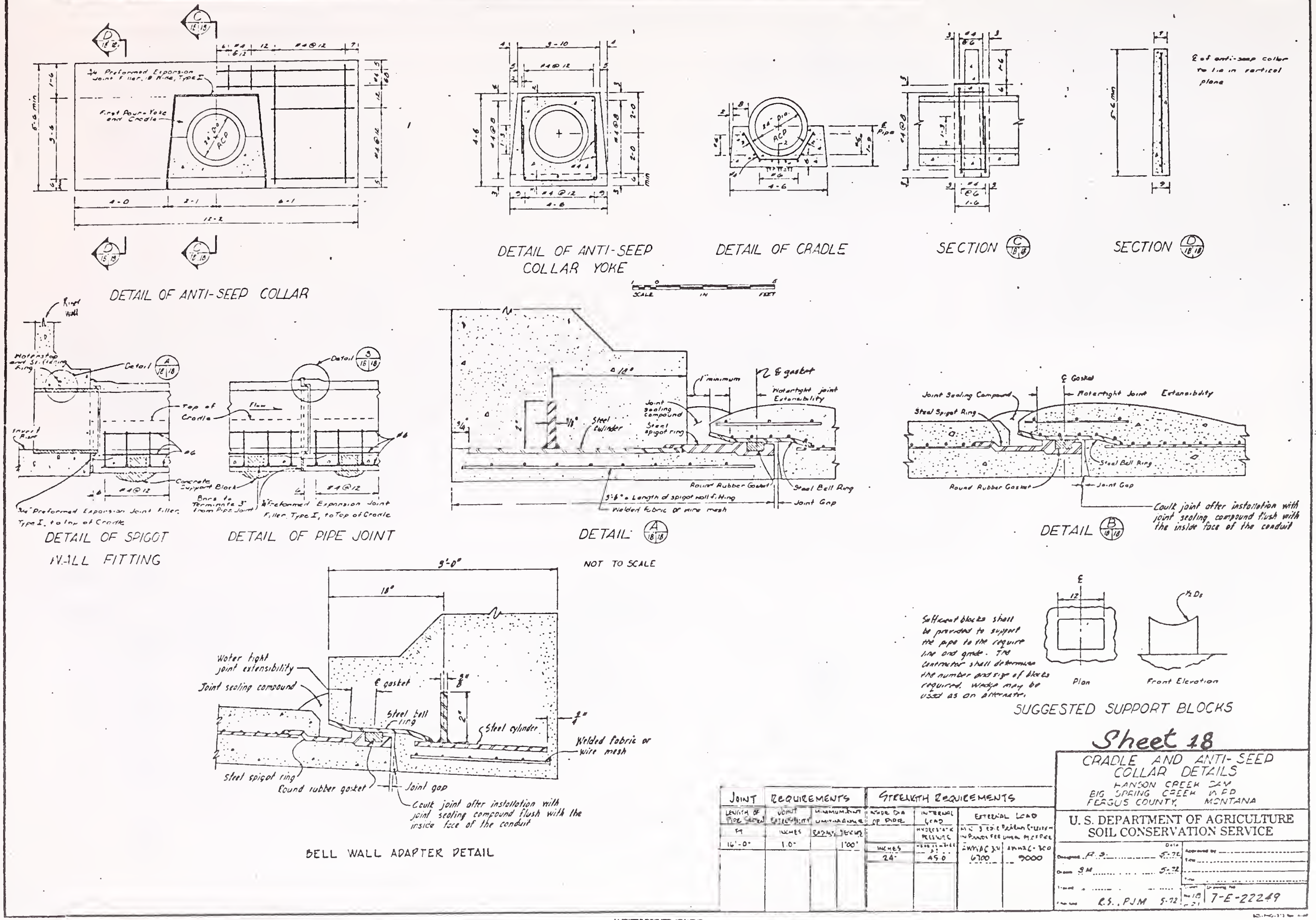

PLAN
DETAILS
TRASH RACK
PLAN
SECTION A
BASE PLATE
COUNTERSINK DETAIL
Note: Place oil seal between gate frame and headwall
DETAIL OIL SEAL
DETAIL STEM SPLICE
DETAIL WEATHER SEAL
DETAIL OPTIONAL OIL FILLER
DETAIL OPTIONAL WEATHER SEAL
GATE STEM SPLICE
NOT TO SCALE
ELEVATION
SIDE VIEW
SECTIONAL ELEVATION
SECTIONAL ELEVATION
SECTIONAL ELEVATION
FRONT ELEVATION
CROSS SECTION
SUPPORT ANGLE DETAIL
PLAN
GATE STEM GUIDE
NOT TO SCALE
PLAN
PLAN
GATE STEM PEDESTAL
PLAN
GATE LIFT PEDESTAL
NOT TO SCALE
Sheet 14
GATE CONTROL DETAILS
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249

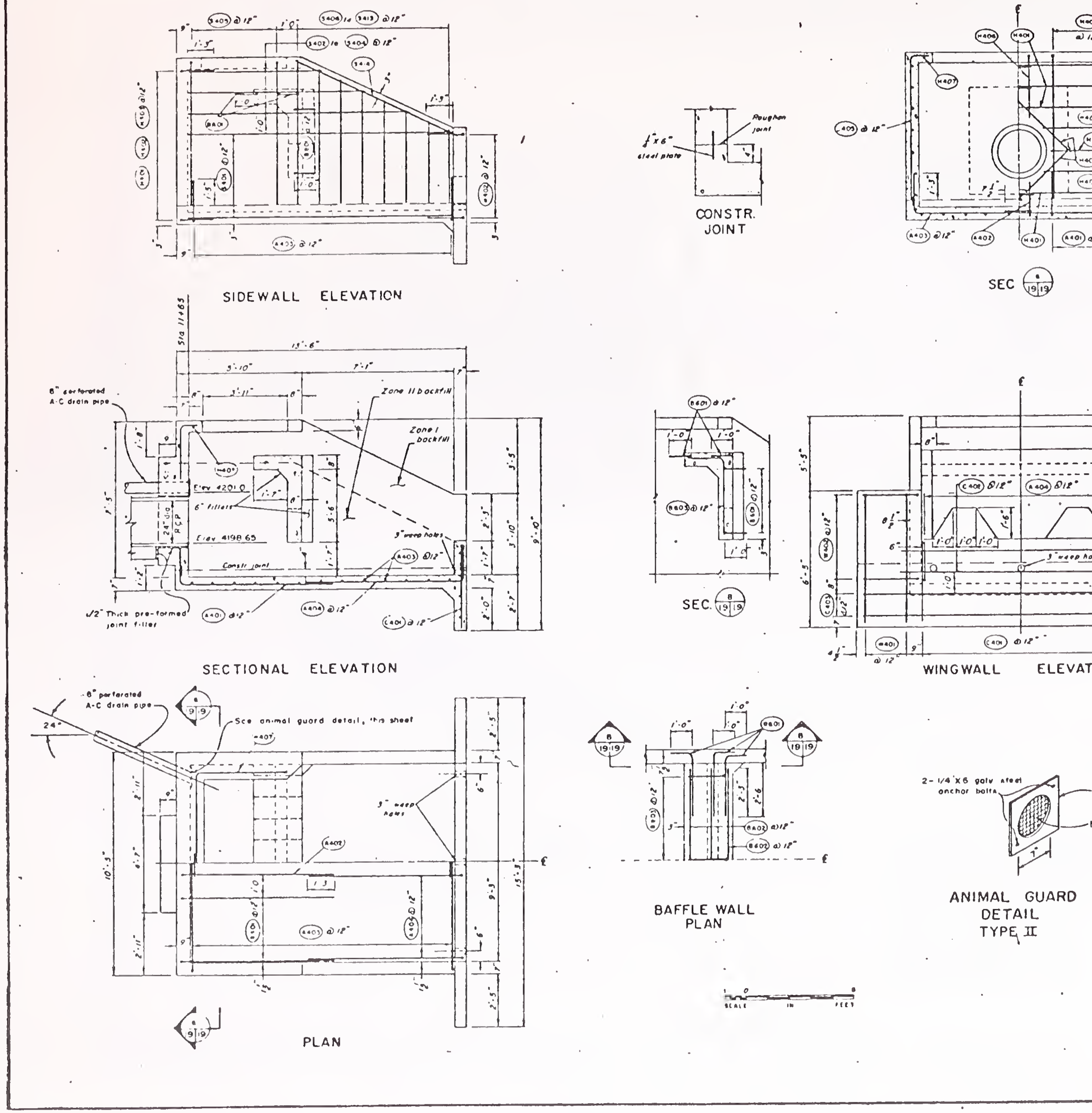

Note: Trim or bend bars to clear manhole frame 2" minimum clearance.
EXPOSED FACE SECTION A
SECTION C
SECTION D
SECTION E
SECTION F
Construction joints see detail sheet 17
UNEXPOSED FACE SECTION A
SECTION G
EXPOSED & TOP FACE SECTION H
UNEXPOSED & BOTTOM FACE SECTION H
Sheet 15
RISER REINFORCEMENT DETAILS
HANSON CREEK DAM
BIG SPRING CREEK W P P
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249



Sheet 16
RISER DETAILS
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249
SECTION A
SECTION B
SECTION C
DETAIL A
RISER PLAN
PLAN - TOP
ISOMETRIC VIEW
NOT TO SCALE
Manhole
Rock rip rap
Elev 4241.0
Elev 4239.0
Elev 4200.0
Zone IV
Constr. jt
3"x9" slots
3"x9" slot
C8 x 11.5 8'-0" long
L 3"x3"x1/4" 5" long
2-1/2"x1 1/2" bolts with hex nuts & washers
30" Dia. manhole frame and solid lid
Construction joint (typ.) see detail sheet 17.
Constr. joint (typ.) see detail sheet 17
See Pipe details sheet 18.
Sta 8+93
Flow


Note: Trim or bend bars to clear notches
Construction joints see detail this sheet
30" Dia Manhole Frame
20'-0"
10'-0"
EXPOSED FACE
SECTION B 13/17
UNEXPOSED FACE
SECTION B 13/17
EXPOSED ¢ TOP FACE
COVER SLAB PLAN
Note: Trim or bend bars to clear frame by 2"
UNEXPOSED ¢ BOTTOM FACE
COVER SLAB PLAN
Note: Weld ¼"x6" steel plate to make continuous throughout construction joint.
¼"x6" steel shear plate.
JOINT DETAIL
(NOT TO SCALE)
Sheet 17
RISER REINFORCEMENT DETAILS
HANSON CREEK DAM
BIG SPRING CREEK W.P.D.
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed J.K. 5-72
Drawn D.R.V. 5-72
Checked K.S. P.J.M. 9-72
Sheet 17 of 21
Drawing No. 7-E-22249


DETAIL OF ANTI-SEEP COLLAR
DETAIL OF ANTI-SEEP COLLAR YOKE
DETAIL OF CRADLE
SECTION C 18/18
SECTION D 18/18
DETAIL OF SPIGOT WALL FITTING
DETAIL OF PIPE JOINT
DETAIL A 18/18
NOT TO SCALE
DETAIL B 18/18
BELL WALL ADAPTER DETAIL
SUGGESTED SUPPORT BLOCKS
Plan
Front Elevation
Sufficient blocks shall be provided to support the pipe to the require line and grade. The contractor shall determine the number and size of blocks required. Wedge may be used as an alternate.
Caulk joint after installation with joint sealing compound flush with the inside face of the conduit
Sheet 18
CRADLE AND ANTI-SEEP COLLAR DETAILS
HANSON CREEK DAM
BIG SPRING CREEK W.P.P.
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
JOINT REQUIREMENTS
STRENGTH REQUIREMENTS
7-E-22249



STEEL SCHEDULE

LOCATION	MARK	SIZE	QUAN	LENGTH	TYPE	A	B	TOTAL LENGTH
Apron	A401	4	8	9'-2"	2	[illegible]	7'-3"	[illegible]
"	A402	4	8	8'-6"	2	1'-0"	7'-3"	[illegible]
"	A403	4	20	7'-9"	2	2'-0"	5'-6"	[illegible]
"	A404	4	10	8'-9"	2	1'-0"	7'-0"	[illegible]
Cutoff wall	C401	4	10	3'-9"	str			37'-6"
"	C402	4	2	11'-3"	str			22'-6"
"	C403	4	2	14'-3"	str			28'-6"
Wingwall	W401	4	6	6'-0"	str			36'-0"
"	W402	4	10	4'-3"	2	1'-9"	2'-6"	42'-6"
Sidewall	S401	4	10	12'-3"	str			122'-6"
"	S402	4	2	10'-3"	str			20'-6"
"	S403	4	2	8'-3"	str			16'-6"
"	S404	4	2	6'-3"	str			12'-6"
"	S405	4	10	7'-6"	2	0'-9"	6'-6"	75'-0"
"	S406	4	2	6'-9"	str			13'-6"
"	S407	4	2	6'-3"	str			12'-6"
"	S408	4	2	5'-9"	str			11'-6"
"	S409	4	2	5'-3"	str			10'-6"
"	S410	4	2	4'-9"	str			9'-6"
"	S411	4	2	4'-3"	str			8'-6"
"	S412	4	2	3'-6"	str			7'-0"
"	S413	4	2	3'-3"	str			6'-6"
"	S414	4	2	8'-0"	str			16'-0"
Headwall	H401	4	10	7'-6"	2	1'-0"	5'-6"	75'-0"
"	H402	4	4	5'-6"	2	1'-0"	3'-9"	22'-0"
"	H403	4	2	5'-5"	2	1'-9"	3'-6"	10'-6"
"	H404	4	8	7'-6"	2	0'-9"	6'-9"	60'-0"
"								
"	H406	4	2	3'-9"	2	0'-6"	3'-0"	7'-6"
"	H407	4	2	6'-3"	2	5'-0"	4'-3"	12'-6"
"	H408	4	4	3'-3"	str			13'-0"
Baffle wall	B601	6	12	3'-9"	2	2'-6"	1'-0"	45'-0"
"	B602	6	6	8'-9"	str			52'-6"
"	B603	6	9	5'-6"	2	1'-0"	3'-6"	49'-6"

BAR TYPES

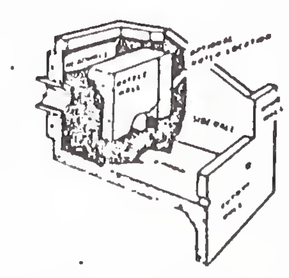
TABLE OF QUANTITIES

	I.D. of pipe In.	ASTM 76 B AWWA C 302 Cu Yds	AWWA C300 & C301 Cu Yds	Steel & C.M.P. Cu Yds
Concrete	21	11.30	—	11.36
	24	11.25	11.21	11.32
	27	11.20	—	11.28
	30	11.14	11.10	11.23
	33	11.08	—	11.18
	36	11.00	10.96	11.12
Reinf. Steel		953 lb		

Sheet 19

IMPACT BASIN SIZE E

PORTLAND OREGON E & W P UNIT

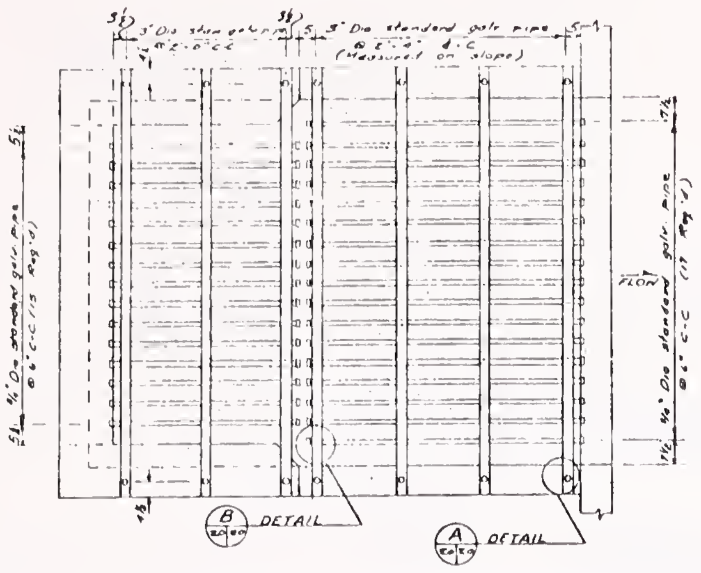


HALF PERSPECTIVE VIEW

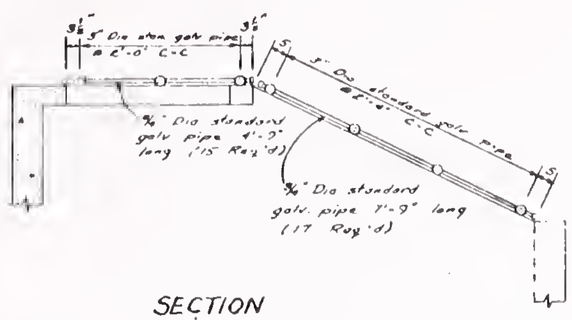
PRINCIPAL SPILLWAY OUTLET
STRUCTURE DETAILS
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed OW	5-72	Approved by
Drawn SCS - VBL	5-72	
Traced		
Checked RS, PJM	6-72	Sheet 19 of 21 — Drawing No. 7-E-22249

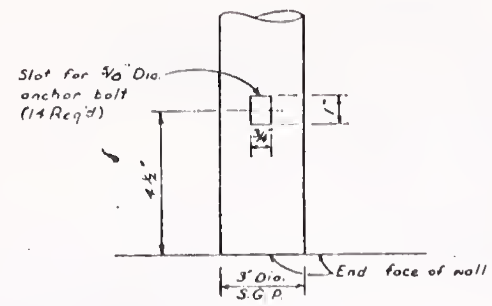


PLAN

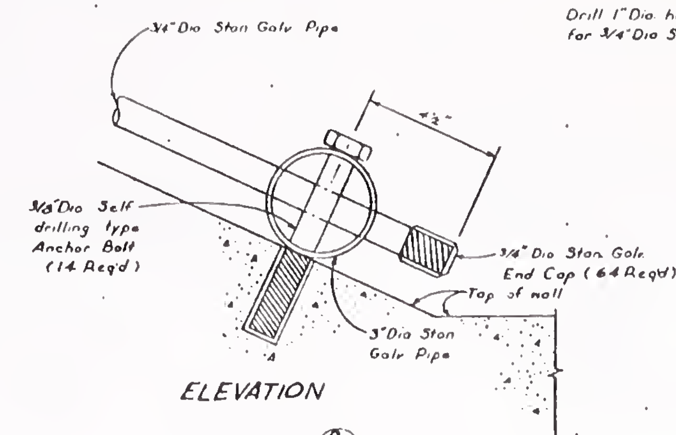


SECTION

OUTLET STRUCTURE SAFETY COVER



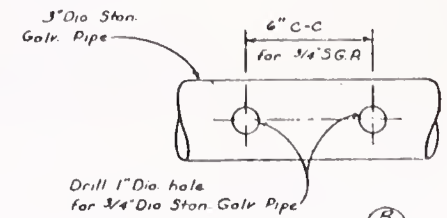
PLAN



ELEVATION

DETAIL (A)

Not to Scale



DETAIL (B)

Not to Scale

BILL OF MATERIAL

ITEM	DIA	LENGTH	QUANTITY
SGP	3"	10'-9"	7
SGP	3/4"	4'-9"	15
SGP	3/4	7'-9	17
End Cap	3/4	—	64
Anchor Bolt	5/8"	—	14

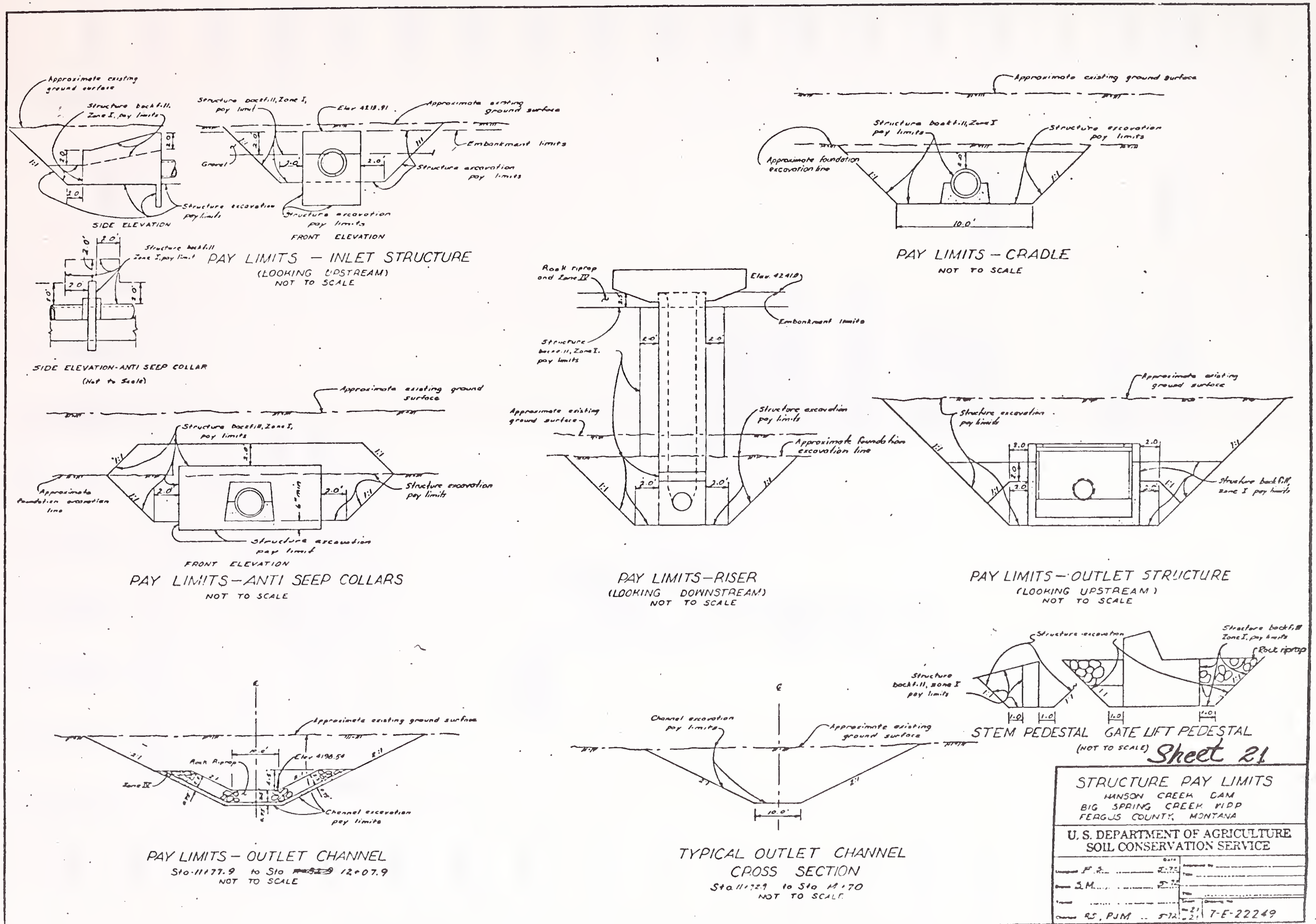
Sheet 20

PRINCIPAL SPILLWAY OUTLET STRUCTURE SAFETY COVER DETAIL

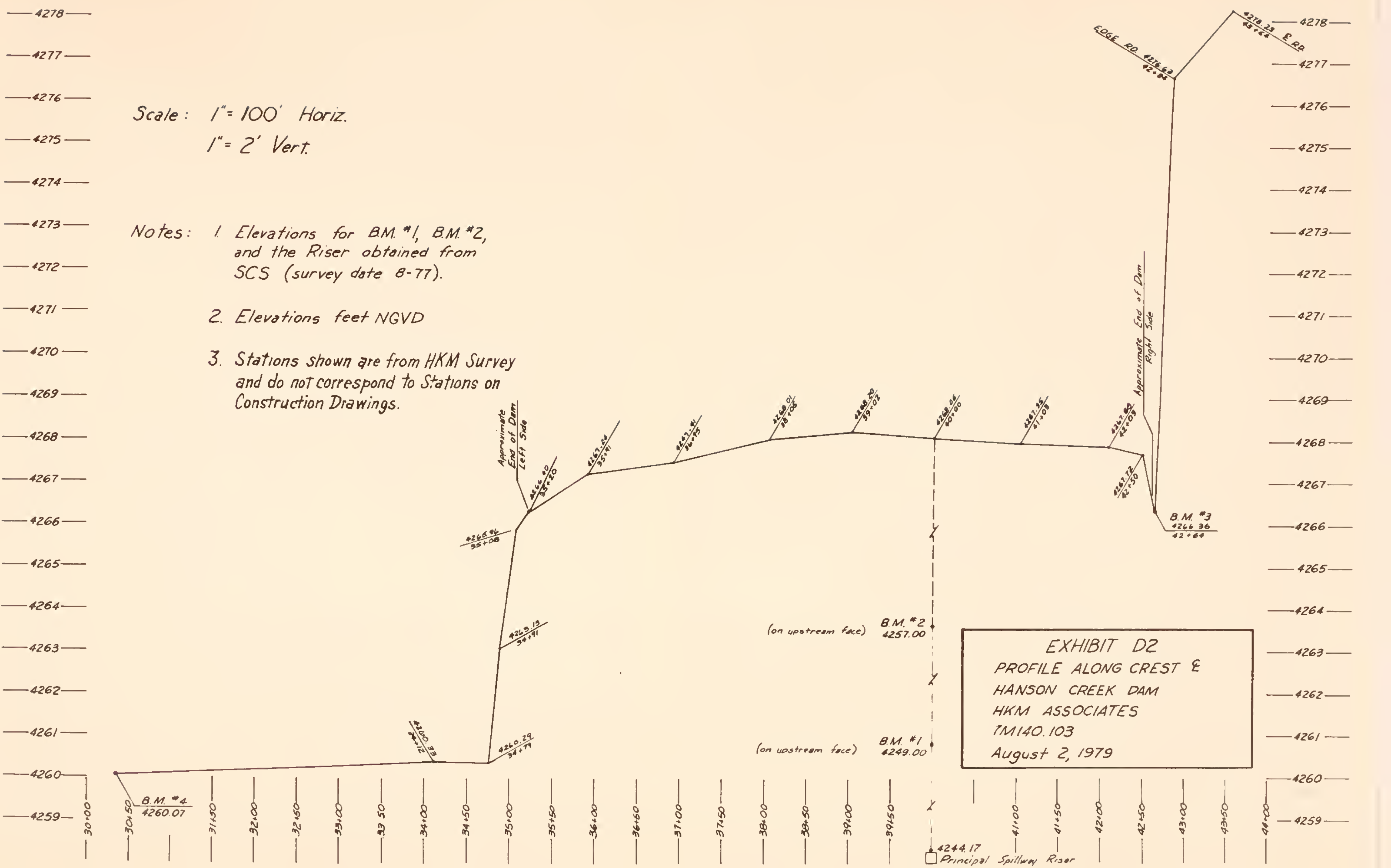
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed R.S.	5-72	Approved by	
Drawn SM	5-72	Title	
Traced RQH-SM	5-72	Sheet No. 20 of 21	Drawing No. 7-E-22249
Checked RS, PJM	5-72		



Approximate existing ground surface
Structure backfill, Zone I, pay limits
SIDE ELEVATION
Structure backfill, Zone I, pay limit
Elev 4219.91
Approximate existing ground surface
Embankment limits
Gravel
Structure excavation pay limits
FRONT ELEVATION
PAY LIMITS - INLET STRUCTURE
(LOOKING UPSTREAM)
NOT TO SCALE
SIDE ELEVATION-ANTI SEEP COLLAR
(Not to Scale)
Approximate existing ground surface
Structure backfill, Zone I, pay limits
Approximate foundation excavation line
Structure excavation pay limit
FRONT ELEVATION
PAY LIMITS-ANTI SEEP COLLARS
NOT TO SCALE
Rock riprap and Zone IV
Elev. 4241.0
Embankment limits
Structure backfill, Zone I, pay limits
Approximate existing ground surface
Structure excavation pay limits
Approximate foundation excavation line
PAY LIMITS-RISER
(LOOKING DOWNSTREAM)
NOT TO SCALE
Approximate existing ground surface
Structure backfill, Zone I pay limits
Structure excavation pay limits
Approximate foundation excavation line
10.0'
PAY LIMITS - CRADLE
NOT TO SCALE
Approximate existing ground surface
Structure excavation pay limits
Structure backfill, Zone I pay limits
PAY LIMITS - OUTLET STRUCTURE
(LOOKING UPSTREAM)
NOT TO SCALE
Structure excavation
Structure backfill, Zone I, pay limits
Structure backfill, Zone I, pay limits
Rock riprap
STEM PEDESTAL
GATE LIFT PEDESTAL
(NOT TO SCALE)
Approximate existing ground surface
Rock Riprap
Elev 4198.54
Zone IV
Channel excavation pay limits
PAY LIMITS - OUTLET CHANNEL
Sta 11+77.9 to Sta 12+07.9
NOT TO SCALE
Channel excavation pay limits
Approximate existing ground surface
10.0'
TYPICAL OUTLET CHANNEL CROSS SECTION
Sta 11+72.9 to Sta 14+70
NOT TO SCALE
Sheet 21
STRUCTURE PAY LIMITS
HANSON CREEK DAM
BIG SPRING CREEK WPP
FERGUS COUNTY, MONTANA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
7-E-22249



Scale: 1" = 100' Horiz.
1" = 2' Vert.
Notes: 1. Elevations for B.M. #1, B.M. #2, and the Riser obtained from SCS (survey date 8-77).
2. Elevations feet NGVD
3. Stations shown are from HKM Survey and do not correspond to Stations on Construction Drawings.
EXHIBIT D2
PROFILE ALONG CREST ℄
HANSON CREEK DAM
HKM ASSOCIATES
7M140.103
August 2, 1979
Approximate End of Dam Left Side
Approximate End of Dam Right Side
EDGE RD. 4276.63 42+84
4278.23 43+64 ℄ RD.
B.M. #4 4260.07
B.M. #3 4266.36 42+64
B.M. #2 4257.00
(on upstream face)
B.M. #1 4249.00
(on upstream face)
4244.17
Principal Spillway Riser
4260.29 34+79
4263.19 34+91
4265.96 35+08
4266.40 35+20
4267.26 35+91
4267.41 36+95
4268.01 38+08
4268.20 39+02
4268.06 40+00
4267.95 41+08
4267.84 42+09
4267.72 42+50
4278
4277
4276
4275
4274
4273
4272
4271
4270
4269
4268
4267
4266
4265
4264
4263
4262
4261
4260
4259
30+00
30+50
31+50
32+00
32+50
33+00
33+50
34+00
34+50
35+00
35+50
36+00
36+50
37+00
37+50
38+00
38+50
39+00
39+50
41+00
41+50
42+00
42+50
43+00
43+50
44+00

HKM ASSOCIATES COMPUTATION SHEET

EXHIBIT D2

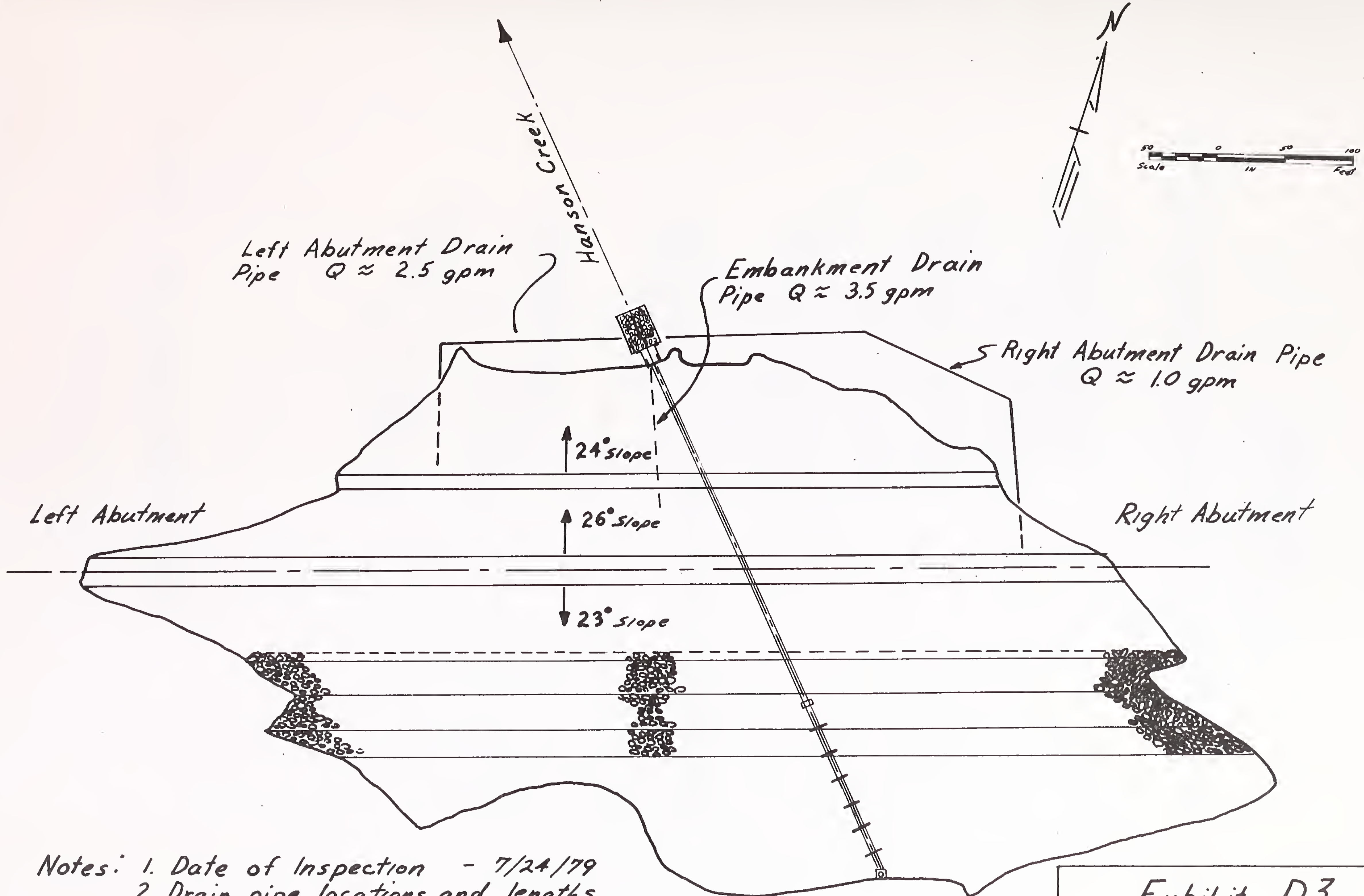
By	Date	Project No.	Sheet
GD	8/2/79	7M140.103	1 of 1

Chkd by	Date	Name
FF	8/17/79	HANSON CREEK DAM CREST SURVEY

Details

Feature: STATION - ELEVATION TABULATION

	STATION ALONG DAM ℄	ELEVATION FT NGVD
BM #4	—	4260.07
	34+12	4260.33
	34+79	4260.29
	34+91	4263.13
	35+08	4265.96
(End of Dam Left Side)	35+20	4266.40
	35+91	4267.24
	36+95	4267.41
	38+05	4268.01
	39+02	4268.20
Beginning Station	40+00	4268.05
	41+03	4267.95
	42+09	4267.88
	42+50	4267.72
(End of Dam, Right Side) B.M. #3	42+64	4266.36
Edge of Road	42+84	4276.63
℄ of Road	43+54	4278.23



Notes: 1. Date of Inspection - 7/24/79
2. Drain pipe locations and lengths Only Approximate
3. Underseepage Quantities Field Estimated

Exhibit D3

Measured Embankment Slopes Hanson Creek Dam

HKM Assoc. 7M140.103

EXHIBIT D4
SOILS DESIGN DATA

The soil properties assigned to the various zones and used in the analysis are:

Zone I (core)
γ moist = 105 pcf
γ sat. = 128.8 pcf
c= 200 psf
ϕ = 19 degrees

Zone II (drain fill)
γ moist = 140.4 pcf
γ sat. = 144.2 pcf
c= 0.0
ϕ = 35 degrees

Zone III (downstream shell)
γ moist = 120.0 pcf
c = 0.0
ϕ = 35 degrees

Zone IV (Zone III transition & rock facing)
γ moist = 140.4 pcf
γ sat. = 144.2 pcf
c = 0.0
ϕ = 35 degrees

Foundation soil
γ sat. = 126 pcf
c = 300 psf
ϕ = 25 degrees

Foundation rock
γ sat. = 170 pcf
c = 12,000 psf
ϕ = 60 degrees

Source: SCS, Design Report, 1972

APPENDIX E

HANSON CREEK DAM
ENGINEERING DATA

Exhibit E1.1	Actual Reservoir Elevation-Capacity Data From The SCS
Exhibit E1.2	Reservoir Area - Capacity Table
Exhibit E2	Reservoir Area - Capacity Curve
Exhibit E3	Discharge Rating Table
Exhibit E4	Discharge Rating Curves

EXHIBIT E1.1

ACTUAL RESERVOIR ELEVATION - CAPACITY DATA

FROM THE

SOIL CONSERVATION SERVICE

Elevation, ft. NGVD	Capacity, AF
4241.0	180
4246.0	267
4252.0	392
4260.0	610
4265.0	800
4265.5	820

EXHIBIT E1.2

RESERVOIR AREA-CAPACITY TABLE

HANSON CREEK DAM

H.K.M. ASSOCIATES
PROJECT NO.:7M140.103
08/31/79
PAGE 2

ELEV FEET NGVD	CAP AREA 0	CAP AREA 1	CAP AREA 2	CAP AREA 3	CAP AREA 4	CAP AREA 5	CAP AREA 6	CAP AREA 7	CAP AREA 8	CAP AREA 9
4220.0	2 4	6 4	10 5	15 5	20 5	26 6	32 6	38 7	45 7	53 8
4230.0	60 8	69 8	77 9	86 9	96 10	106 10	117 11	128 11	139 12	152 12
4240.0	164 13	178 14	192 15	207 15	223 16	240 17	257 18	276 19	295 20	316 21
4250.0	337 22	360 23	383 24	408 25	433 26	460 27	487 28	516 29	545 30	576 31
4260.0	608 32	642 34	677 36	714 38	752 40	793 42	836 44	880 46	927 48	976 50

NOTES : AREA IN ACRES
CAPACITY IN ACRE-FEET
CALCULATION BY CONIC METHOD
ABOVE TABULATION ONLY AN APPROXIMATION USING A SELECT NUMBER OF DATA POINTS PROVIDED BY THE SCS (SEE EXHIBIT E1.1) — COMPLETE TABULATION NOT AVAILABLE

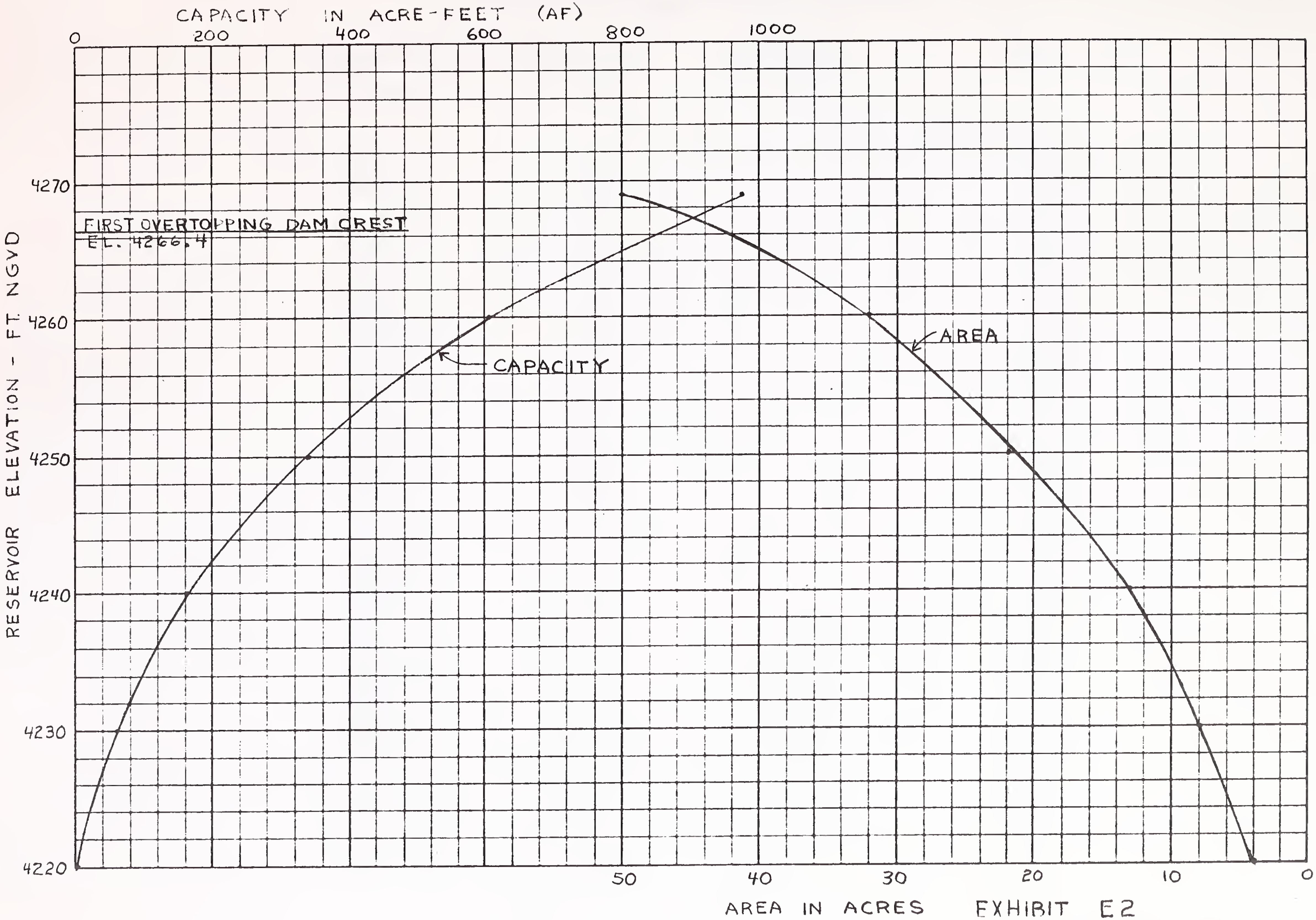


EXHIBIT E2
RESERVOIR AREA-CAPACITY CURVE
HANSON CREEK DAM

EXHIBIT E3

HANSON CREEK DAM
RATING TABLE

	ELEVATION (FT NGVD)	PRINCIPAL SPILLWAY	EMERGENCY SPILLWAY	TOTAL
	4241.0	0.		0.
	4241.5	14.		14.
	4242.0	38.		38.
	4243.0	81.		81.
	4244.0	82.		82.
	4245.0	83.		83.
	4246.0	84.		84.
	4247.0	85.		85.
	4248.0	86.		86.
	4249.0	87.		87.
	4250.0	88.		88.
	4251.0	89.		89.
	4252.0	90.		90.
	4253.0	91.		91.
	4254.0	92.		92.
	4255.0	93.		93.
	4256.0	94.		94.
	4257.0	94.		94.
	4258.0	95.		95.
	4259.0	96.		96.
	4260.0	97.		97.
	4261.0	98.	400.	498.
	4262.0	99.	1,507.	1,606.
	4263.0	100.	3,273.	3,373.
	4264.0	100.	5,675.	5,775.
	4265.0	101.	8,698.	8,799.
	4265.5	102.	10,437.	10,539.
	4266.0	102.	12,329.	12,431.
FIRST OVERTOPPING DAM CREST EL	4266.4	102.	14,400	14,502.
	4268.0	104.	21,378.	21,482.
	4270.0	105.	32,764.	32,869.

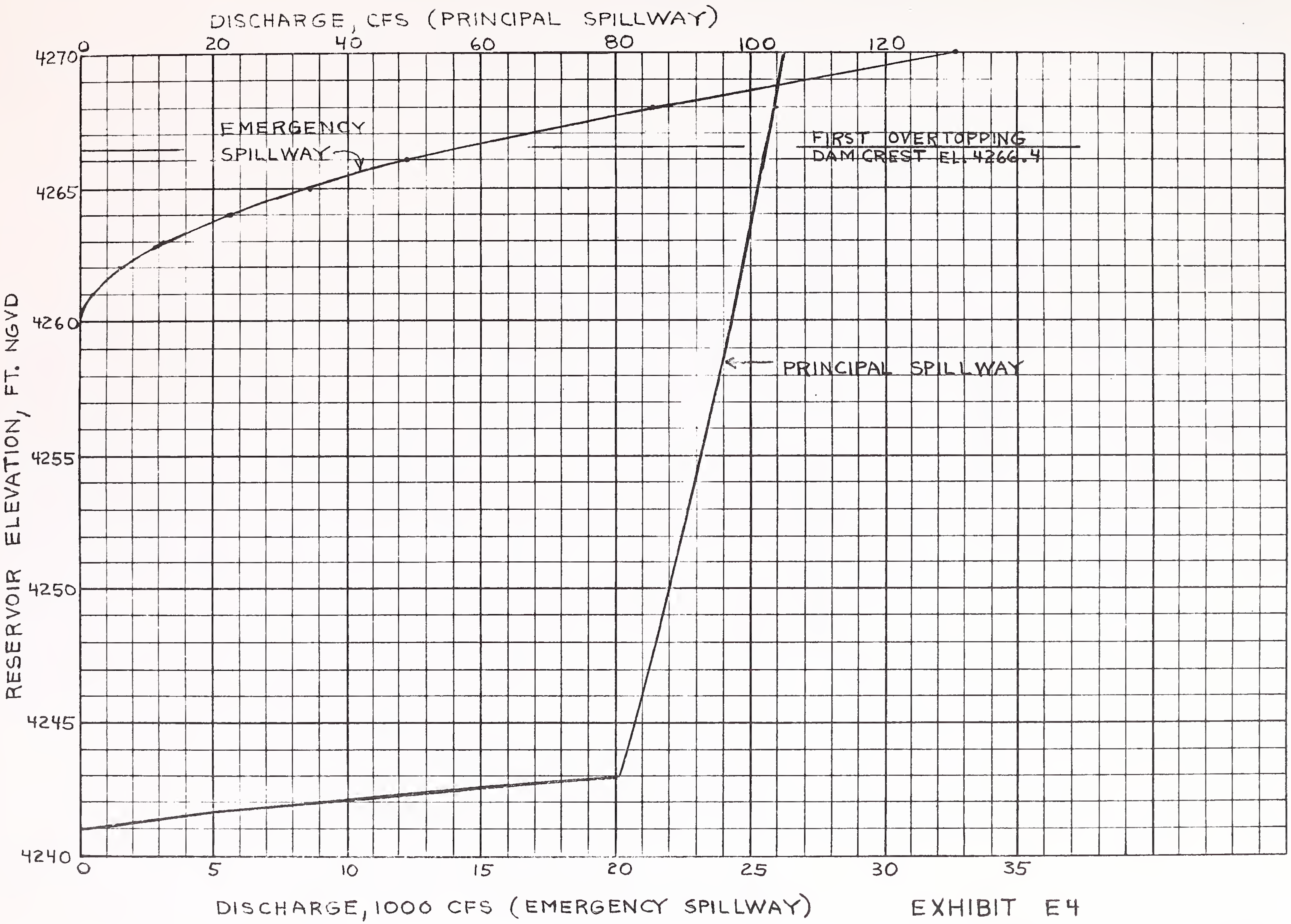


EXHIBIT E4
DISCHARGE RATING CURVES
HANSON CREEK DAM

APPENDIX F

HANSON CREEK DAM - CORRESPONDENCE

CECIL HOWE
FRANK "BUD" KAMP
First Ward Aldermen

WALTER WRIGHT
C. WILBUR LINDSTRAND
Second Ward Aldermen

ROBERT H. GREEN
ALVIN HECKFORD
Third Ward Aldermen

JOHANNA HEINTZ
City Treasurer

T.D. "SAM" TURNER
City Judge

THOMAS EVANS
Building Official

CITY of LEWISTOWN

312 4th AVENUE SOUTH — LEWISTOWN, MONTANA 59457 — (406) 538-8768
ROBERT E. LaFOUNTAIN, MAYOR

ROBERT L. KNOPP
City Attorney

RUSSELL L. DUNNINGTON
Police Chief

SONNY MOLINE
Fire Chief

TERRY MEEHAN
Supt. of Operations

WENDY PAYE
City Clerk

MARJORY J. KELLER
Water Clerk

EDWARD F. BERGER
Recreation Director

December 9, 1980

Leon K. Moraski
District Engineer
Seattle District, Corps of Engineers
P O Box C-3755
Seattle, Washington 98124

Dear Mr. Moraski:

The City of Lewistown appreciates the opportunity to review the final draft report on Hanson Creek Dam (MT 1570) We have the following comments:

We feel that an event of the magnitude of the Probable Maximum Flood using Corps of Engineers guidelines is unrealistic when compared to the hydrological history of Central Montana. Please include the probability of occurence of the PMF in your report.

The recommendations referring to an emergency warning plan, inspections, repairs and monitoring programs do have merit and will receive consideration by the City of Lewistown.

Apparently other districts of the Corps of Engineers apply different criteria for establishing the PMF. We would suggest more uniformity in application of the "Recommended Guidelines for the Safety Inspection of Dams." by the COE.

Sincerely,

Robert E. LaFountain

Robert E. LaFountain
Mayor

REL/wp

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

December 8, 1980

Ralph Morrsion
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Hanson Creek Dam (MT-1570). We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

Thank you for this opportunity to review and comments on the final report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/LT/lj
Enclosure

United States Department of Agriculture

Soil Conservation Service

P.O. Box 970
Bozeman, MT
59715

November 13, 1980

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on Hanson Creek Dam (MT-1570).

Our comments relating to specific report statements are:

Page 22: Give reference for pattern "e". Describe rainfall distribution used. Give time of concentration used.

Page 29, line 13: As shown on Sheet 7 of the construction drawings, the embankment drain pipe extends into both abutment drainage zones. This was done to provide an additional backup outlet. Thus, the seepage from the embankment cannot be differentiated from that of the abutments. The observed seepage was 7 gpm, compared to a design estimate of 10.7 gpm. As the drain pipes were encased in drain fill material designed to convey the design seepage in case of pipe failure, it is true that the observed seepage may only represent a portion of the total.

Page 32, line 13: We strongly disagree with the statement that "any plant growth in the riprap area will cause rapid deterioration of the riprap....". By what mechanism does this suggestion of rapid deterioration occur? In practice, plant growth on riprap is encouraged to concentrate fines, resist bedding scour, and help increase resistance to tractive forces of ice and water. The presence of water loving plants does not indicate a high concentration of fines as many grow in gravel. As the embankment is greater than 150 feet thick at permanent pool, root penetration is not of concern even if they had a desire to grow away from water.

Page 35, line 18: Add "(non-emergency)" after "unsafe".

Page 40, line 2: SCS criteria precludes the use of a gate on a spillway intended to be uncontrolled (without full-time attendant). With improper operation and management, the gate could be closed during flood events less than design flood, increasing the probability of structure failure over that of a short-term pressurized conduit condition.

We do not agree with the hydrologic conditions used to develop the probable maximum flood. The conditions selected attempt to eliminate the element of risk to a degree that we feel is not practical or reasonable. Despite the climatic differences, the Omaha District appears to be imposing much more reasonable hydrologic conditions than is the Seattle District. We suggest that a common degree of risk (probability) be applied by the COE nationwide.

Sincerely,

C. E. Ogle

For Van K Haderlie
State Conservationist

cc:
Ray Smith, Acting SCE, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

10 FEB 1981

Mr. Van K. Haderlie
State Conservationist
U.S. Department of Agriculture
Soil Conservation Service
P.O. Box 970
Bozeman, Montana 59715

Dear Mr. Haderlie:

Thank you for reviewing and commenting on the Phase I Dam Safety Inspection Report drafts on Big Casino Creek Dam, MT-1569; East Fork Dam, MT-1567; Hanson Creek Dam, MT-1570; and Pike Creek Dam, MT-1568. Although you submitted a separate response letter for each report draft, we are responding with a single letter. All your comments were considered in preparing the final reports. The following discusses major points of interest that were addressed and questioned in your letters.

With regard to the SCS criteria that "precludes the use of a gate on a spillway intended to be uncontrolled," our evaluations reveal that the principal spillway conduit for these dams with the exception of Pike Creek conduit (orifice plate prohibits pressurization) could be pressurized for several days while a flood is being accommodated. If a pressurized conduit that extends through an earthen embankment experiences difficulties during the period of pressurization, and there isn't any means to facilitate upstream emergency closure, the dam could be lost. We recommended that the principal spillway systems be modified to provide the ability to close these lines. In our opinion, the resulting increase in project safety that would be obtained by installing an upstream closure capability far outweighs the possible danger that might be brought about by mismanagement; especially since controls could be locked in the open position and operated similarly to the present way the outlet works are controlled.

The Probable Maximum Flood is, by definition, the largest flood that could be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The Seattle District's PMF derivation and routing methods used in the Phase I dam safety studies are based on Corps-approved criteria and procedures; and are designed to evaluate in a relatively quick and preliminary way a project's capability to safely handle

NPSEN-FM
Mr. Van K. Haderlie

a guideline-recommended SDF. These methods have been successful in identifying projects with hydrologic shortcomings and the results of the studies, in several cases, have been verified by independent reviews. Our studies indicate that Big Casino, East Fork, Pike Creek and Hanson Creek Dams can only handle from 21 to 35 percent of the PMF volumes, depending on the project, before these dams are overtopped and subsequently failed, and this causes us concern. We recognize there are differences between PMF derivation procedures used by the Corps and the SCS. Irrespective of these differences, our hydrologic concerns have been verified in an independent review by the Soil Conservation Service, West Technical Support Center (TSC). The TSC reviewed the inspection report drafts and the original project design and concluded that these projects will be overtopped by approximately 3 to 7 feet, depending on the project. Attached for your information is the Corps' response letter to the City of Lewistown (inclosure 1), which contains additional information on the TSC review. Inclosures 2 through 5 are the City of Lewistown's responses to the inspection report drafts.

In conclusion, based on the results of our studies and the independent TSC review, it is our opinion that the recommendations as outlined in section 3.2 of the subject dam safety inspection reports be implemented as soon as possible, and that the SCS make every effort to assist the City of Lewistown in the recommended engineering studies.

Sincerely yours,

LEON K. MORASKI
Colonel, Corps of Engineers
District Engineer

5 Incl
As stated

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT. CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE. WASHINGTON 98124

10 FEB 1981

NPSEN-FM

Honorable Wilbur Lindstrand
Mayor of Lewistown
Lewistown, Montana 59457

Dear Mayor Lindstrand:

We would like to thank the City of Lewistown for comments regarding the Phase I Dam Safety Inspection Draft Reports on East Fork Dam, MT-1567; Pike Creek Dam, MT-1568; Big Casino Creek Dam, MT-1569; and Hanson Creek Dam, MT-1570. Although the City submitted a written response for each report draft, the comments were similar in nature for all the dams, consequently we are responding with this one letter.

The inspection criteria used for these projects were those established by the "Recommended Guidelines for the Safety Inspection of Dams," which represents the comprehensive consensus of the engineering community. Federal and state agencies that engage in the design and construction of dams, professional engineering societies, consulting engineers, and university engineers were involved directly and indirectly in the preparation of the guidelines.

The criteria for the spillway design floods (SDF) as outlined in the guidelines were based on the dam heights, reservoir depths, and downstream hazard potentials of the projects. The recommendation to use the Probable Maximum Flood (PMF) as the SDF for each project is predicated on the desire to provide protection for downstream human life and property. If a flood smaller than the PMF were utilized as the SDF, a flood could then occur in the vicinity of an earthen dam, which is larger than the dam could safely handle, and the dam would be overtopped and subsequently failed. There is considerable difference in the effects and damage to human life and property, between a dam failure with a resultant fast moving surge of water traveling downstream, and the relatively slower rising downstream water depths caused by a natural flooding condition. Thus, the PMF is used to eliminate the probability of a dam being overtopped and failed.

The PMF is, by definition, the largest flood that could be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region and, therefore, no probability of occurrence can be assigned. However, smaller floods approaching the magnitude of a PMF can and do occur. In June, 1921, much of Eastern Montana experienced a very severe rainstorm which produced rainfall in excess of 14 inches during a 35-hour period

over a 100 square mile area, and almost 12 inches during the same period over an area of 1,000 square miles. In June 1964, northwestern Montana experienced a storm that approximated 76 percent of the PMF. The storm extended about 200 miles northward along the Continental Divide from Helena to southern Alberta, Canada, in a band about 70 miles wide. Precipitation during this 36-hour storm period was as much as 14 inches, while only 2.7 inches (with a potential of 22.7 inches) fell in the Lewistown area. In the State of Montana, dams were overtopped and failed, 35 lives were lost, 350 persons injured, and about 8,700 persons were evacuated. Numerous buildings, roads and bridges were damaged or destroyed. The total Montana damage is estimated to be $55 million (1964 dollars). The City of Lewistown experienced $15,500 of damage, due to the storm-related flooding, even though the storm was not centered near Lewistown. A map (inclosure 1) copied from a U.S. Geological Survey Publication entitled, "Floods of June 1964 in Northwestern Montana," which illustrates the extent and precipitation magnitudes of the Montana storm, has been inclosed for your information.

The PMF derivation and routing methods used in these dam safety studies are based on Corps-approved criteria and procedures, and are designed to evaluate in a relatively quick and preliminary way a project's capability to safely handle a SDF. We would appreciate receiving and discussing with you the information that has lead the City to believe that other Corps Districts are applying different criteria for establishing the PMF. We recognize that refinements in our preliminary PMF could either increase or decrease the final flood estimate and, due to the limited scope of a Phase I dam safety inspection, no dam breach analyses were performed. Consequently, we recommend more detailed hydrologic and hydraulic routing studies to fully evaluate the project's hydrologic and hydraulic capabilities. Please note that the results of our Phase I studies indicate that these projects can only handle from 21 to 35 percent of the PMF volumes, depending on the project. Therefore, it is possible that these dams could be overtopped and subsequently failed by storms much smaller than the PMF.

The Seattle District provided the U.S. Soil Conservation Service (SCS) report drafts prior to submitting the drafts to the City of Lewistown and the State of Montana for review and comment. Based on instructions from the SCS national headquarters, the four report drafts were reviewed by the SCS West-Technical Service Center in Portland, Oregon. The Technical Center also reviewed the SCS' original design for these four dams to ascertain whether they met current SCS design criteria. This review showed the original SCS design contained a factor which is no longer accepted by the SCS in computing the time of concentration (Tc) for their spillway design flood. In addition, the drainage areas were reviewed and corrections made. The review also utilized an updated probable maximum precipitation (PMP) as obtained from a more recent Weather Service publication. When the SCS Technical Center recomputed their design floods using this revised data, they found that Big Casino Creek, East Fork, Hanson Creek and Pike Creek Dams overtopped by approximately 4 feet, 7 feet, 3 feet and 3 feet, respectively. Inclosure 2 is the SCS computation data that was provided to the Corps by the SCS Technical Service Center.

In summary, both the Corps evaluation and independent SCS review indicate the need for additional engineering studies. Because of the potential threat to Lewistown, we recommend that you give these matters serious consideration.

Sincerely yours,

LEON K. MORASKI
Colonel, Corps of Engineers
District Engineer

2 Incl
as

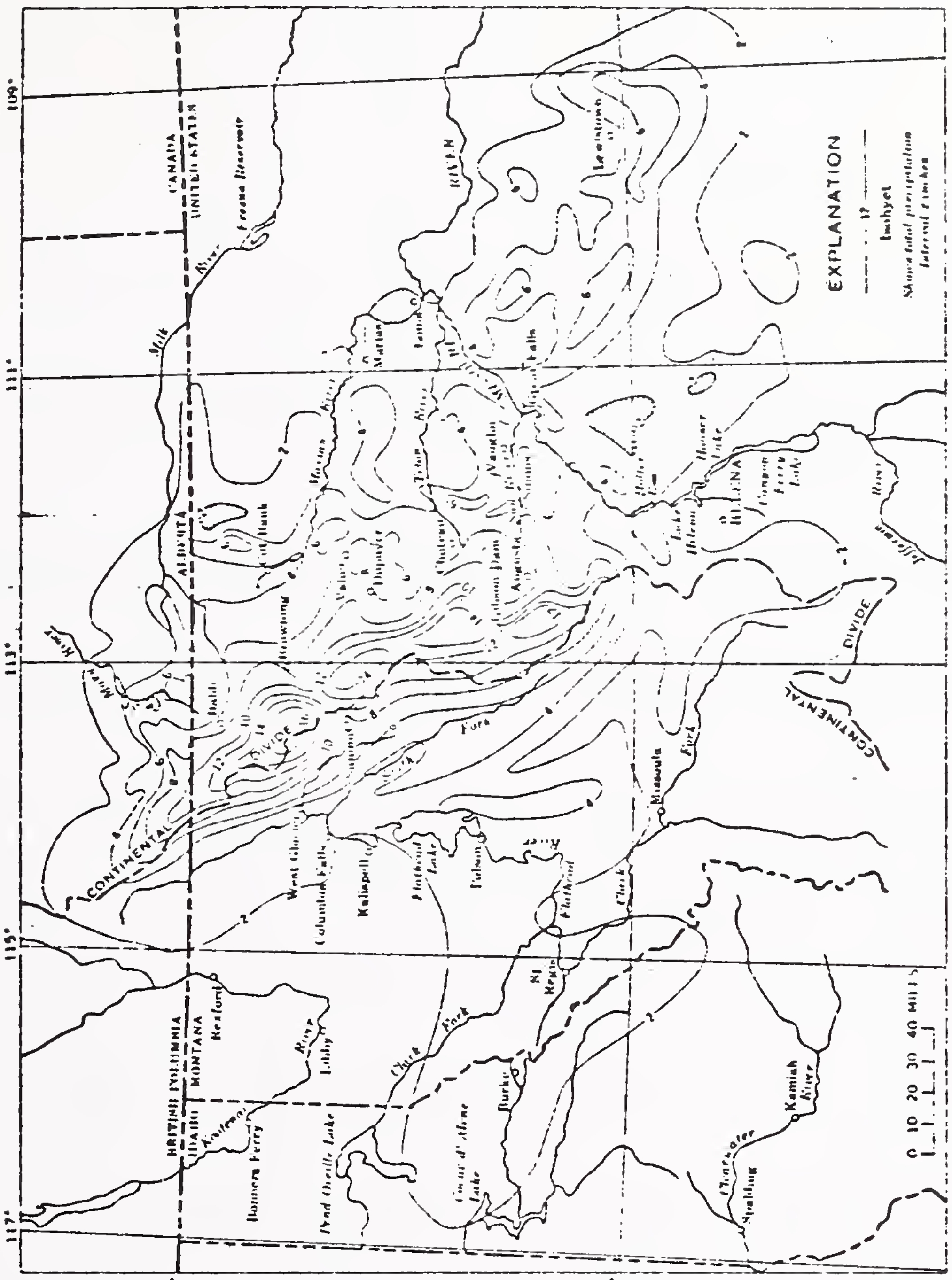


FIGURE 13.—Total precipitation for June 7–8, 1964. Note centers of high intensity rainfall near crest of Continental Divide. Highest centers estimated because of lack of measurements in mountains. Owing to the natural variability of rainfall in rugged mountain country such as this, caution is recommended in interpolating from this chart.

REFERENCE: Boner and Stermitz, "Floods of June 1964 in Northwestern Montana," U.S. Department of Interior, Geological Water-Supply Paper 1840-B, 1967.

Incl-1

Structure Routings — GLC Sept. 1980

Big Spring Creek Watershed, Montana

Dam	New Drainage Area, Mi.^{2}	Old Drainage Area Mi.^{2}	New Time of Concentration Hours	Old Time of Concentration Hours	Existing Top of Dam Elev	Top of Dam - Existing sh TP-38 PMP	Existing Spillway Width, Feet	Existing Spillway Crest Elev.
Pike	7.45	7.70	3.0	6.0	4169.0	4170.54	200.0	4161.7
Hanson	9.85	7.80	2.5	5.0	4265.5	4267.69	400.0	4260.0
Big Casino	19.82	18.90	4.1	10.0	4075.0	4077.87	350.0	4068.0
East Fork	60.9	61.8	7.5	18.0	4413.0	4417.58	400.0	4405.0

	Existing Top of Dam	SCS 6 hr PMP Interim	SCS 24 hr PMP	SCS 24 hour Hydrograph peak	SCS 24 hour Hydrograph volume	CE 72 hour PMF peak	CE 72 hour PMF volume
Pike	4169.0	4171.28	4171.66	15750	6914	30170 cfs	6000 Ac Ft.
Hanson	4265.5	4268.19	4268.36	23630	9408	38100	6280
Big Casino	4075.0	4078.54	4079.09	34115	17925	53240	14230
East Fork	4413.0	4418.99	4420.08	63900	48033	138290	56400 ~~[illegible]~~

	Design FB Hydrograph peak	Design FB Hydrograph volume
Pike	7885	4263
Hanson	9617	4514
Big Casino	14380	11894
East Fork	23910	34740

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Fig. 6-2